The Forest

ZX Spectrum version, August 1983

This document is a collection of copies of the original design notes, source code print-outs, diagrams and publication information for the second published version of The Forest. It represents an archive of what was possible in a machine using an 8-bit microprocessor (Z80) and only 48 kilobytes of programmable memory.

My first personal computer was a TRS-80 Model 1 Level II and I have written separately (a document similar to this) about how the first version of The Forest was written for that and published in March 1983.

I then bought a Sinclair ZX Spectrum. It also used the Z80 processor, so much of my code was immediately transferable. However the Spectrum had a completely different way of displaying graphics, and in colour rather than monochrome. It also had a rather different flavour of BASIC for the higher level programming.

The machine had an interpreter for the programming language BASIC. That was stored in read-only memory (ROM) which was immediately available when power was switched on. Programs could either be typed into the remaining random-access memory (RAM) or be loaded from audio cassette tapes. One such program was an editor/assembler which made it possible to write additional programs in the Z80 machine code and save those on audio tape for reloading.

This version of The Forest was published by Phipps Associates, a company in South London.

The Forest was one of the earliest attempts to make a simulation of a sport: orienteering. That is, cross-country navigation on foot with map and compass to visit set control points in a planned order.

My particular innovation was to devise a way to generate limitless terrain from a very small amount of program code. The terrain was contoured and had several different types of vegetation plus towns and lakes. It had various kinds of point features dotted around, such as boulders and ponds.

Although I demonstrated that detailed terrain could be generated, the display hardware in those days was extremely limited. So a version of the program was made to output all of the map data as if surveying a real forest. Then the map could be drawn and printed just as we did for real orienteering events (I had been doing some of that since 1973). The published program was therefore accompanied by a full-colour printed map. This was seen as an advantage because it made it difficult to copy the product. People did not have colour printer/copiers in those days either.

The Z80 is fundamentally an 8-bit processor but with 16-bit memory addressing, allowing up to 64 kilobytes of memory. My Spectrum had the full 64kb, comprising 16kb of ROM plus 48kb of RAM. Some of the 8-bit registers could be programmed as pairs to facilitate 16-bit integer arithmetic.

For The Forest I had no access to any floating-point arithmetic so I had to make some interesting design choices in the first, TRS-80, version which I kept for the Spectrum version. For the (x, y) position of the orienteer on the map I used 3-byte

fixed-point numbers: 2 bytes for the integer part and 1 byte after the decimal point. In my design notes it is written as HL.A to use the 16-bit HL register pair and the 8-bit accumulator. This enabled the map to have a width and height of 65km before repeating but the orienteer could be positioned to 1/256 of a metre. That was necessary to allow forward motion on any bearing, using sines and cosines. Which raised another point: how to do trigonometry without floating point? The answer involved 2 more design choices. Firstly compass bearings were “b-degrees” of which I had 256 to a complete circle: one byte’s worth. Bearings therefore had a resolution of 360 / 256 or about 1.4 degrees, more than accurate enough for an orienteer reading a compass. Then sines and cosines were looked up in a table of byte values, each being 128 times the true value and so represented as signed 1-byte integers. The table only needed 64 entries because values in the 4 quadrants are simply related. Also the table as read from the beginning gave sines but read backwards from the end it gave cosines. All to save memory and it worked very well.

The BASIC ROM had a floating-point calculator using 5-byte numbers (1 byte for the exponent). When I got the Melbourne House book of its full disassembly it was made clear that the calculator was not designed for speed. It would not have been fast enough for my purposes. Remember also that the clock speed was only about 4MHz.

The maps

The next 2 pages show the printed orienteering maps which accompanied the published program. It has to be admitted that in the first one the contours are not very realistic. That was the only map issued for the TRS-80 version. While converting the program to run on the Spectrum I developed a much more realistic terrain generator which resulted in the second map, “The Complex Forest”. As will be shown in the listings this involved substituting a chunk of code in the terrain generator and providing a switching mechanism in the BASIC program. There are pages below which explain the difference in detail. (The same could be done retrospectively in the TRS-80 version if anyone is interested. I have discovered that there are enthusiasts still running those machines and resurrecting code such as mine.)

Graham Relf August 2022

Revised February 2025 to include typed main BASIC listing (pp 62 - 68)

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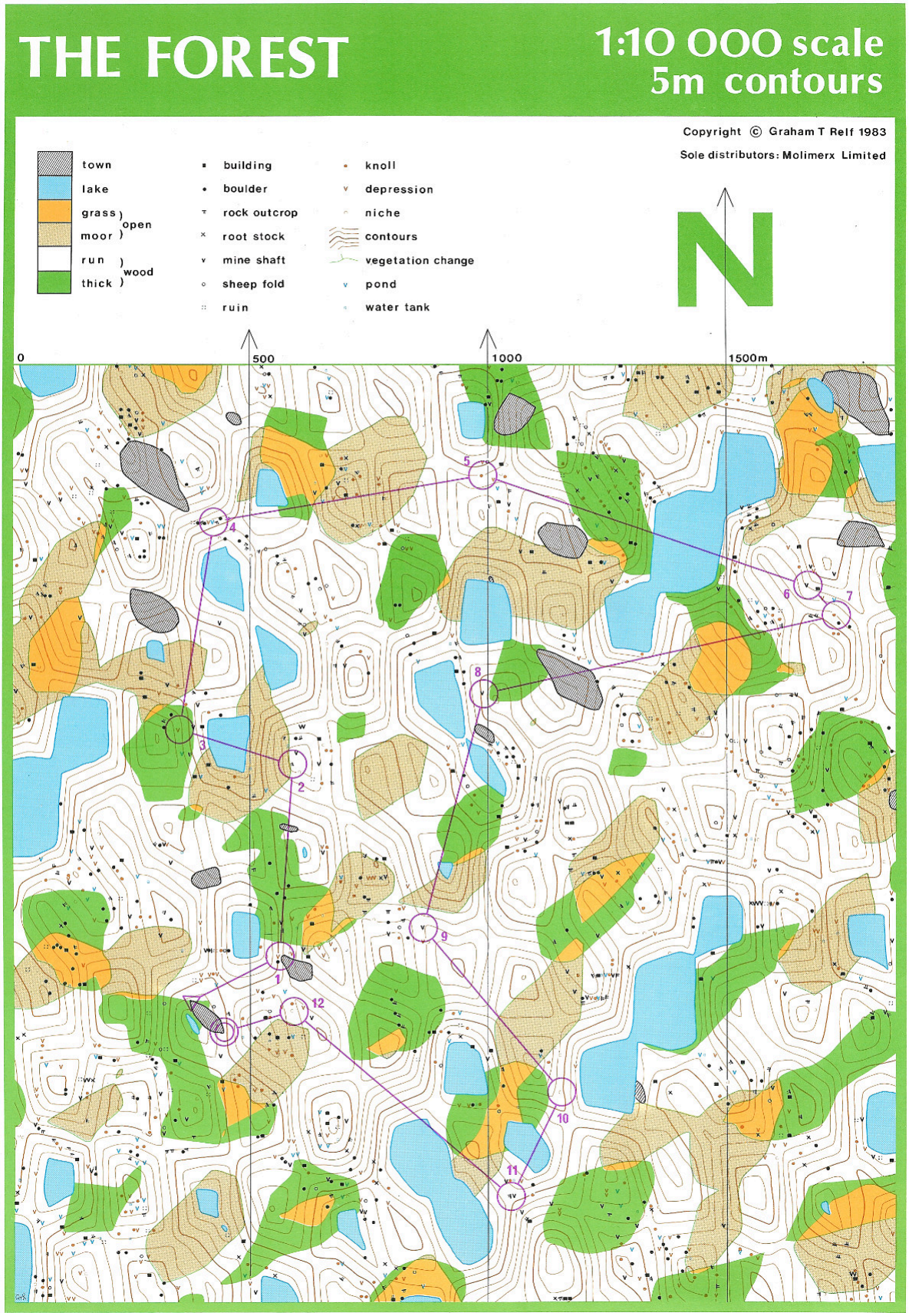
THE FOREST
1:10 000 scale
5m contours
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open
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thick
wood
building
boulder
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knoll
depression
niche
contours
vegetation change
pond
water tank
N
0
500
1000
1500m
1
2
4
5
6
7
8
9
10
11
12

THE COMPLEX FOREST

1:10 000 scale
5m contours

Survey by G Relf & C Barrington-Brown
Cartography by Graham T Relf
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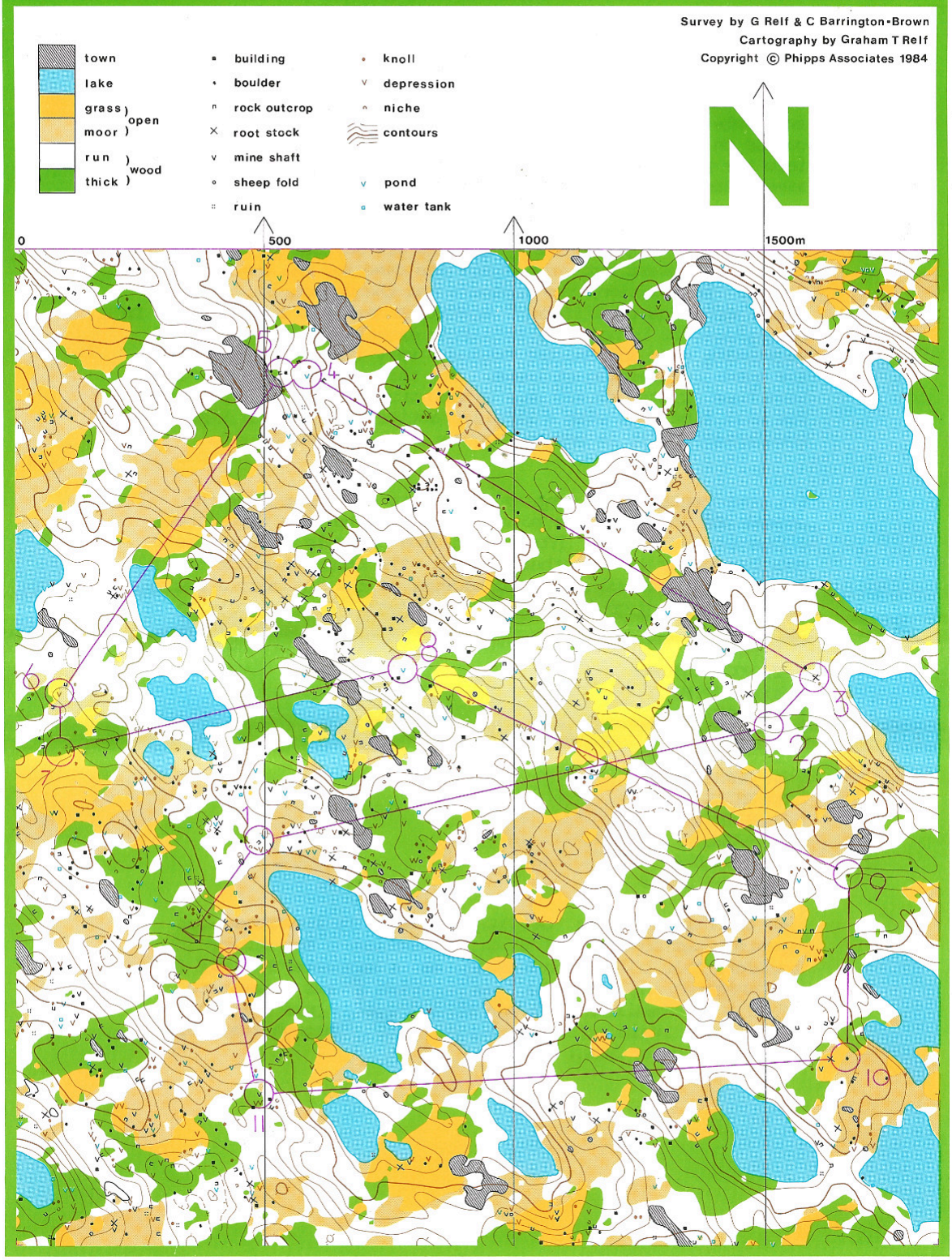

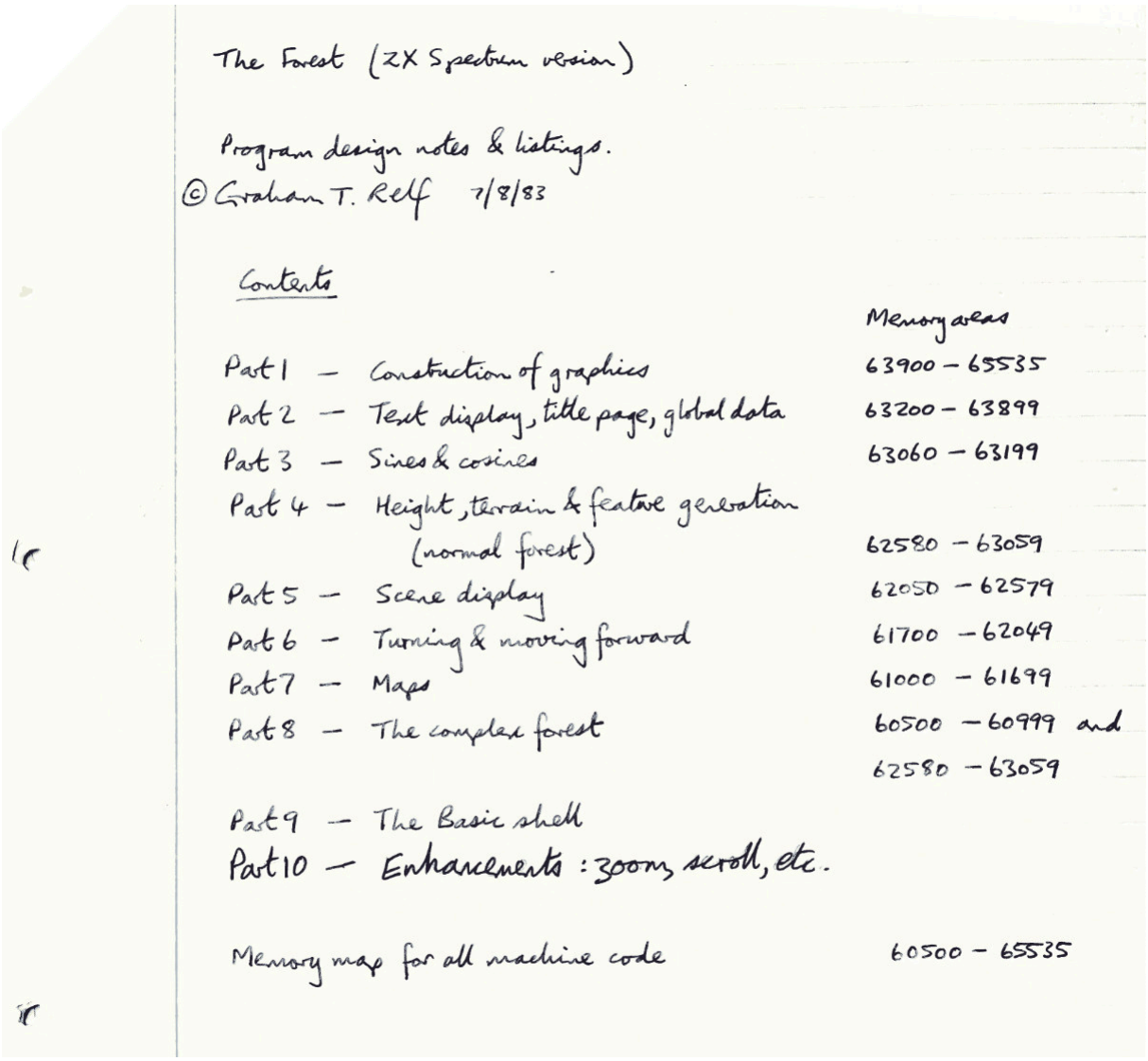

The Forest (ZX Spectrum version)

Program design notes & listings.
© Graham T. Relf 7/8/83

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Memory map for all machine code		60500 – 65535

Many of the pages in this document are snapshots of my original handwritten notes.

But later you will see that I have provided most assembler routines as text, to facilitate possible reuse. If this typed-in code doesn't work I think the most likely cause will be that I have got addresses wrong in the various EQU lines. I have included some pages with memory maps which could be checked against the EQUs.

*Since 2014 I have redeveloped **The Forest** using more recent technology: Javascript running in browsers. This has made it possible to do far more things in the program and with much better graphics: photographs of real trees and landscape features, plus detailed contour maps to proper orienteering standards. This new version may be played for free at grelf.itch.io/forest It includes a lengthy treasure hunt as well as the orienteering courses.*

The Forest (ZX Spectrum version). Program design notes & listings.
Graham T. Relf 7/8/83

Part 1 — Construction of graphics.

In the displayed scene terrain types (except grass) and control flags are shown by graphical symbols. Each symbol is stored in memory as a 'graphic string' of special characters together with steering bytes. There is a machine code routine 'grafprint' which can display such a symbol anywhere on the screen, performing any necessary clipping, given the start address of the string and the starting address in the attributes part of the Spectrum screen map for the desired position.
The format of a graphic string is as follows.

For each character to be displayed:

byte no.	contents	
1	Attributes code	} standard Sinclair meaning
2..9	Pixel bytes, from top down	} standard Sinclair meaning
10	Offset in attr. file to next display position. Offset 0 means end of graphic string.	

It is important to understand the memory mapping of the screen in the Spectrum. Binary pixel information is stored in a bit pattern in a display file starting at 4000H mapping 192 lines of 256 pixels each. Colour attributes are stored on a character basis (8×8 pixels each, 32×24 on the screen) one byte per character in an attribute file starting at 5800H. The attribute file maps the screen in a conventional fashion line by line from top left. The display file is much more complicated and is divided into three 64-line portions. The following two pages describe the layout of the display file.
Then follow the definitions of the special character sets used to construct the terrain symbols for The Forest, then a listing of program forgraf which compiles the graphics into graphic strings for display by the machine code routine which follows that.

ZX Spectrum

Orders of storing 32-byte scan lines (0..191) in display file:

4000H

0, 8, 16, 24, 32, 40, 48, 56, A

1, 9, 17, 25, ... 57,

2, 10, ... etc. 58,

3, 11, ... 59,

4, 12, ... 60,

5, 13, ... 61,

6, 14, ... 62,

7, 15, ... 63,

4800H

64, 72, 80, 88, 96, 104, 112, 120,

57×32 = 1824

A

65, ... 121,

66, ... 122,

67, ... 123,

68, ... 124,

69, ... 125,

70, ... 126,

71, ... 127,

5000H

128, 136, 144, 152, 160, 168, 176, 184,

1824

129, ... 185,

130, ... 186,

131, ... 187,

132, ... 188,

133, ... 189,

134, ... 190,

135, ... 191.

↑ offsets to scroll up one char.

⇒ 5800H address of line start in display file = display file start

+32 * [64 * (line no DIV 64)

+ 8 * (line no MOD 8)

+ (line no MOD 64) DIV 8]

: line no = 0..191, scan lines from top of screen downwards.

To compute address of line start in display file:

Consider bit patterns:

line no	=	$b_7 b_6 b_5 b_4 b_3 b_2 b_1 b_0$	
64*(lineno DIV 64)	=	$b_7 b_6 \phi \phi \phi \phi \phi \phi$	= lineno AND 192
lineno MOD 64	=	$\phi \phi b_5 b_4 b_3 b_2 b_1 b_0$	= line no AND 63
(lineno MOD 64) DIV 8	=	$\phi \phi \phi \phi \phi b_5 b_4 b_3$	= (RSHIFT)^3(lineno AND 56)
lineno MOD 8	=	$\phi \phi \phi \phi \phi b_2 b_1 b_0$	= line no AND 7
8*(lineno MOD 8)	=	$\phi \phi b_2 b_1 b_0 \phi \phi \phi$	= (LSHIFT)^3(lineno AND 7)

⇒ address of line start = display file start
+ 32 * $b_7 b_6 b_2 b_1 b_0 b_5 b_4 b_3$

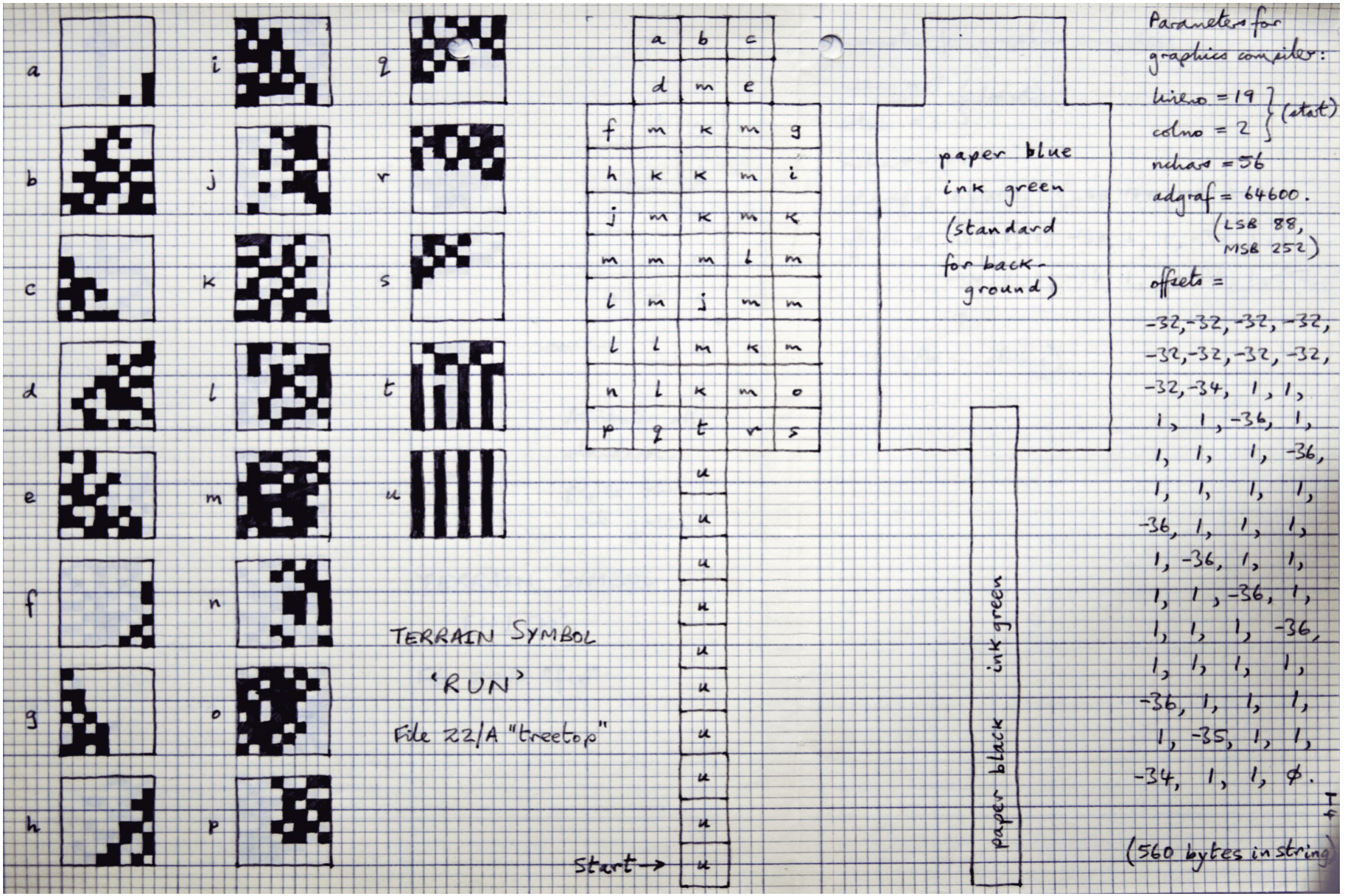
display file start = 16384 = 64*256

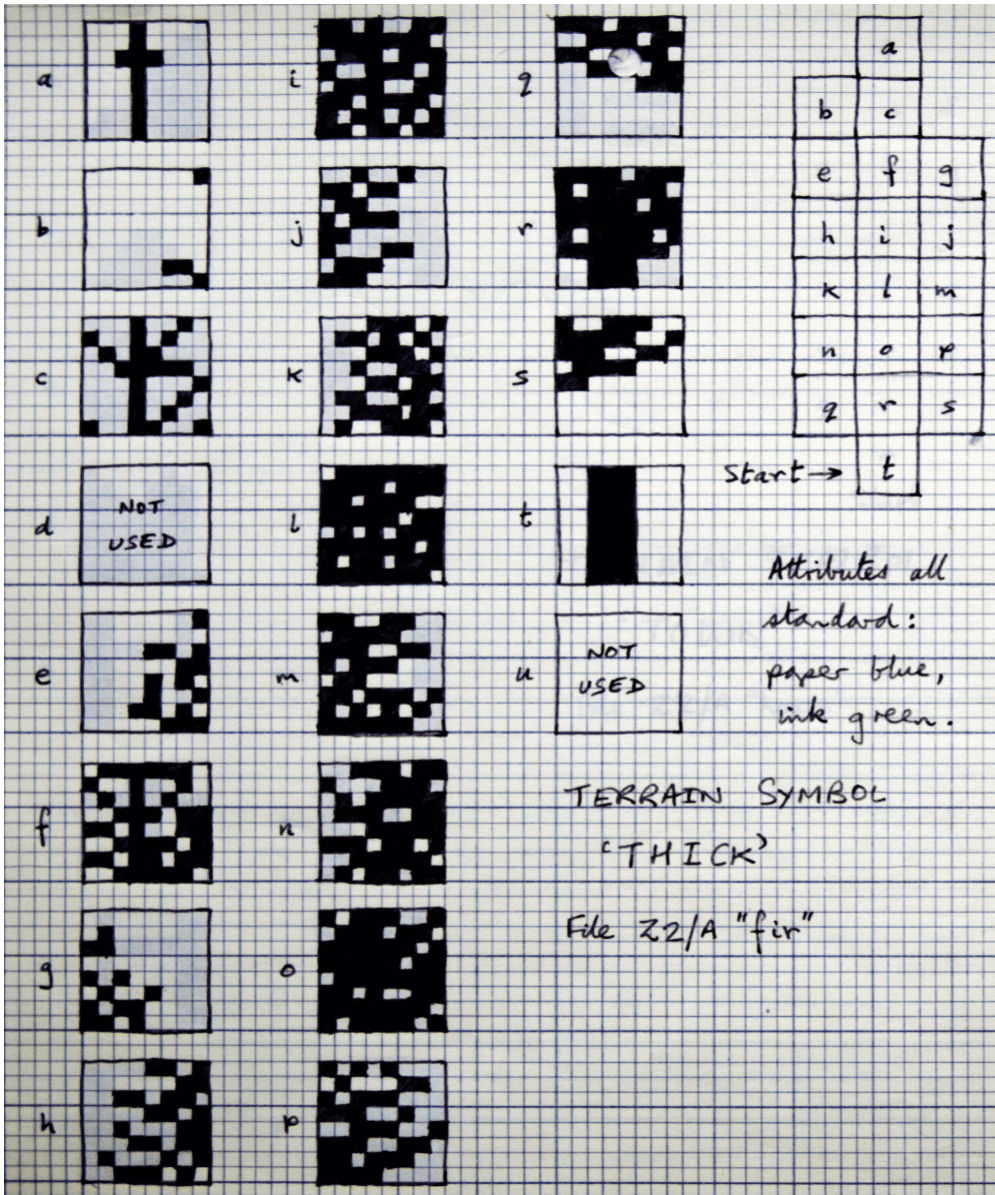
⇒ address of line start = $\boxed{\phi 1 \phi b_7 b_6 b_2 b_1 b_0 \mid b_5 b_4 b_3 \phi \phi \phi \phi \phi}$

Let the byte no. (column) in the line be $\phi\phi\phi a_4 a_3 a_2 a_1 a_0$ (i.e. $\phi..31$)

⇒ address of byte for scan line b, column a

= $\boxed{\phi 1 \phi b_7 b_6 b_2 b_1 b_0 \mid b_5 b_4 b_3 a_4 a_3 a_2 a_1 a_0}$


a b c
d m e
f m k m g
h k k m i
j m k m k
m m m l m
l m j m m
l l m k m
n l k m o
p q t r s
u
u
u
u
u
u
u
u
u
u
u
u
Start→
TERRAIN SYMBOL
'RUN'
File 22/A "treetop"
paper blue
ink green
(standard
for back-
ground)
paper black ink green
Parameters for
graphics compiler:
linno = 19
colno = 2
} (start)
nchars = 56
adgraf = 64600.
(LSB 88,
MSB 252)
offsets =
-32,-32,-32,-32,
-32,-32,-32,-32,
-32,-34, 1, 1,
1, 1,-36, 1,
1, 1, 1,-36,
1, 1, 1, 1,
-36, 1, 1, 1,
1,-36, 1, 1,
1, 1,-36, 1,
1, 1, 1,-36,
1, 1, 1, 1,
-36, 1, 1, 1,
1,-35, 1, 1,
-34, 1, 1, ϕ.
(560 bytes in string)



	a	
b	c	
e	f	g
h	i	j
k	l	m
n	o	p
q	r	s
Start→	t	

Attributes all standard: paper blue, ink green.

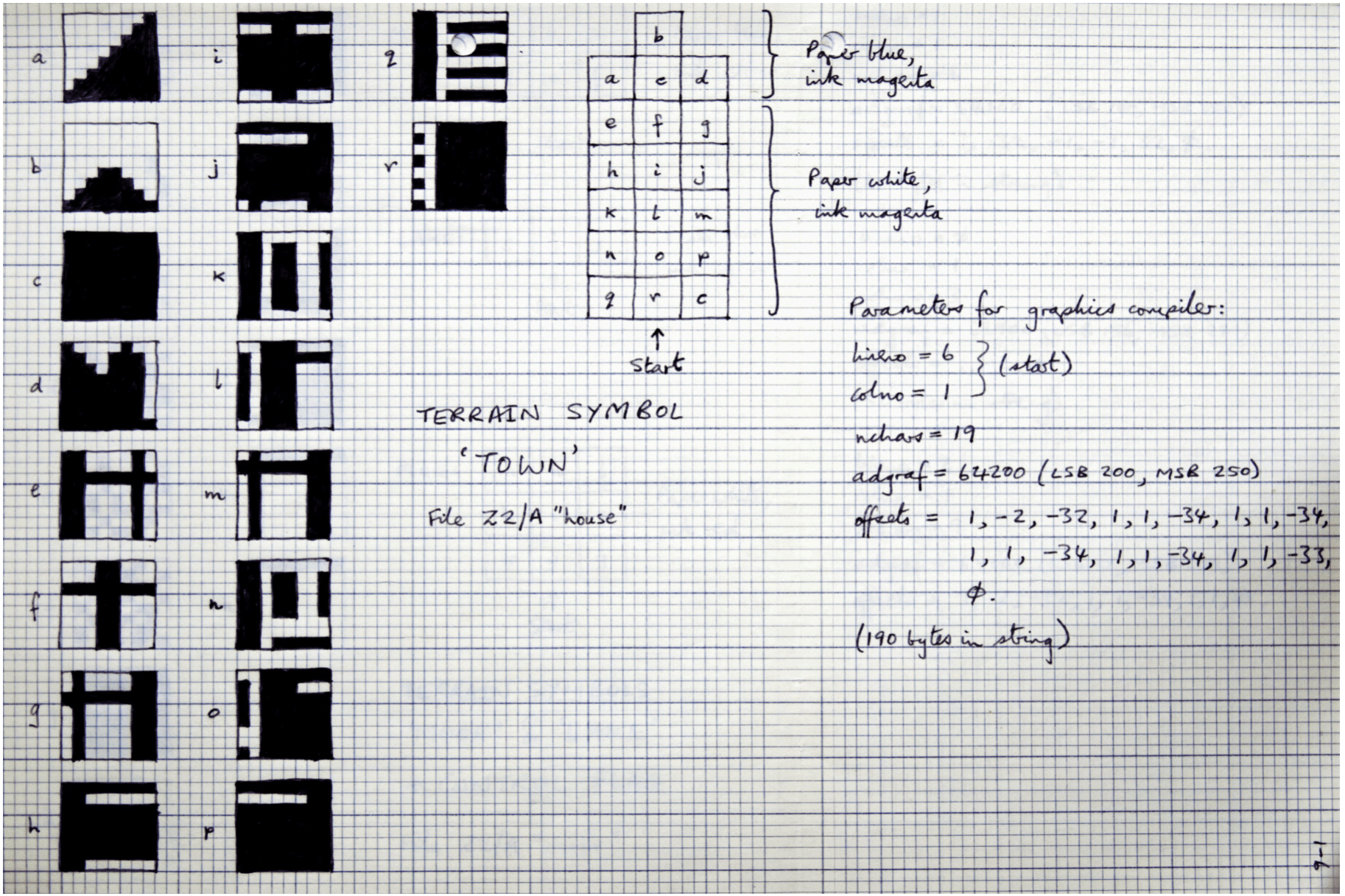
TERRAIN SYMBOL 'THICK'

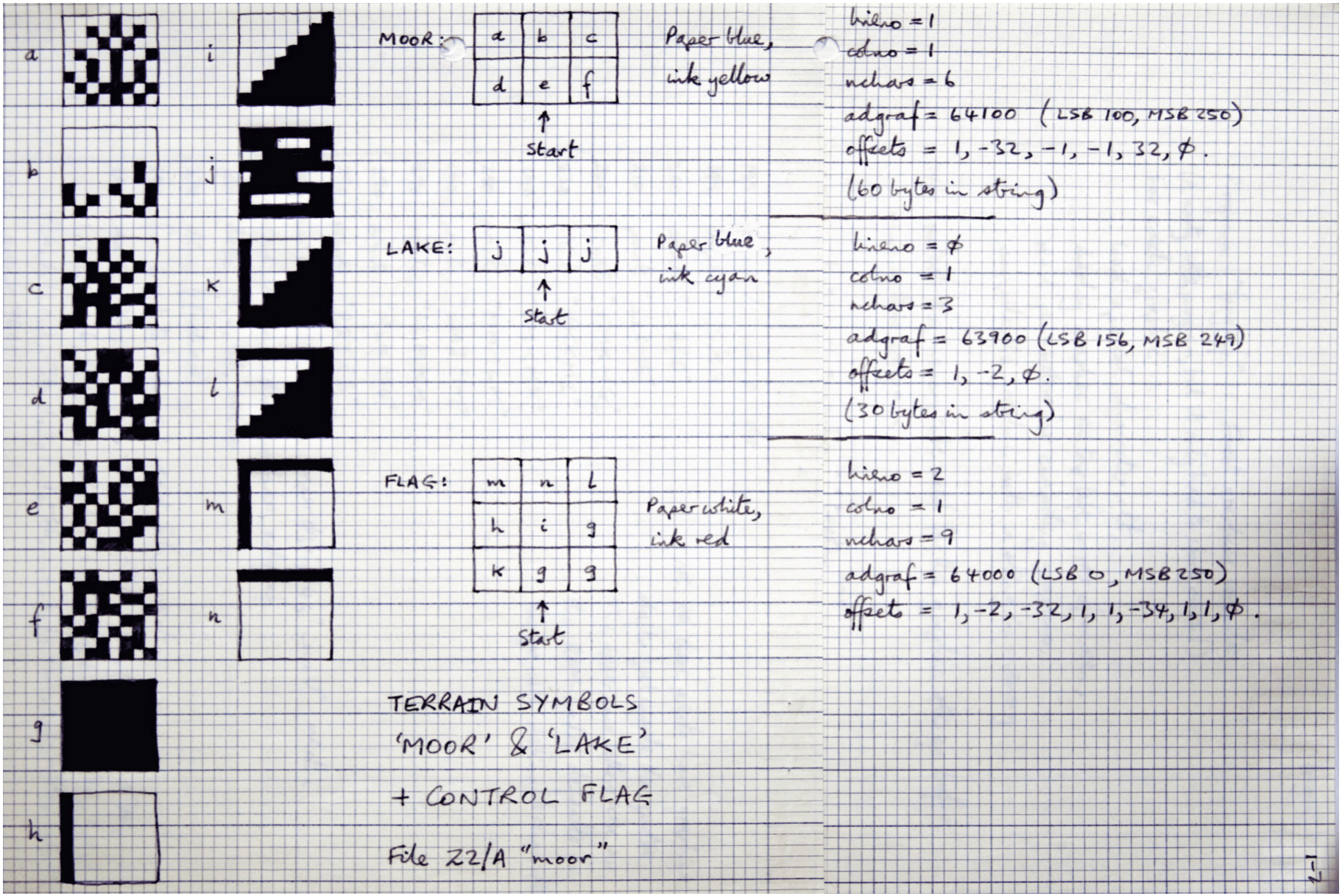
File Z2/A "fir"

Parameters for graphics compiler:

hileno = 7 } (stat)
colmo = 1 }
nchars = 19
adgraf = 64400. (LSB 144, MSB 251)
offsets = -33, 1, 1, -34, 1, 1, -34, 1, 1,
-34, 1, 1, -34, 1, 1, -34, 1, -32,
0.

(190 bytes in string)


a
i
q
b
j
r
c
k
d
l
e
m
f
n
g
o
h
p
b
a c d
e f g
h i j
k l m
n o p
q r c
Start
Paper blue, ink magenta
Paper white, ink magenta
TERRAIN SYMBOL
'TOWN'
File 22/A "house"
Parameters for graphics compiler:
linno = 6
colno = 1
(start)
nchars = 19
adgraf = 64200 (LSB 200, MSB 250)
offsets = 1, -2, -32, 1, 1, -34, 1, 1, -34,
1, 1, -34, 1, 1, -34, 1, 1, -33,
0.
(190 bytes in string)


a
b
c
d
e
f
g
h
i
j
k
l
m
n
MOOR:
a b c
d e f
start
Paper blue, ink yellow
LAKE:
j j j
start
Paper blue, ink cyan
FLAG:
m n l
h i g
k g g
start
Paper white, ink red
TERRAIN SYMBOLS
'MOOR' & 'LAKE'
+ CONTROL FLAG
File 22/A "moor"
linen o = 1
colno = 1
nchars = 6
adgraf = 64100 (LSB 100, MSB 250)
offsets = 1, -32, -1, -1, 32, 0.
(60 bytes in string)
linen o = 0
colno = 1
nchars = 3
adgraf = 63900 (LSB 156, MSB 249)
offsets = 1, -2, 0.
(30 bytes in string)
linen o = 2
colno = 1
nchars = 9
adgraf = 64000 (LSB 0, MSB 250)
offsets = 1, -2, -32, 1, 1, -34, 1, 1, 0.
2-1

Program "forgraf" : Forest graphics compiler.
(A nasty little program, but it only had to work once!)
For each graphic :
load special character slt,
display graphic in top left corner of screen,
read parameters for compiling graphic,
compile the graphic into a string in memory.

NB: protect the memory to be used for the graphic strings before running this program.

```
180 print "Start tape for ""treetop"""
190 load "treetop" code
195 paper 7: ink 0: cls
199 paper 1: ink 4
200 print "␣ABC"
210 print "␣DME"
220 print "FMKMG"
230 print "HKKMI"
240 print "JMKMK"
250 print "MMMLM"
260 print "LMJMM"
270 print "LLMKM"
280 print "NLKMO"
290 print "PQTRS"
300 for i=1 to 10: print paper 0; ink 4; "␣␣U": next i
350 read lineno, colno, nchars, adgraf
360 data 19,2,56,64600
370 dim f(nchars)
380 for i=1 to nchars: read f(i): next i
390 data -32,-32,-32,-32,-32,-32,-32,-32,-32,-34,
    1,1,1,1,-36,1,1,1,1,-36,1,1,1,1,-36,1,1,1,1,-36,1,1,1,1,
    -36,1,1,1,1,-36,1,1,1,1,-36,1,1,1,1,-35,1,1,-34,1,1,0
400 gosub 9600
```

NB: All these prints have graphics shifts just inside the quotes. The upper case letters here are the ROM-loaded defaults for the user-definable characters.

forgraf2
1-9

```
470 input "Next?" ; a$
480 print at 20,0; "Start tape for ""fir"""
490 load "fir" code
495 paper 7: ink 0: cls
499 paper 1: ink 4
500 print " A"
510 print "BC"
520 print "EFG"
530 print "HIJ"
540 print "KLM"
550 print "NOP"
560 print "QRS"
570 print " T"
600 read lineno, colno, nchars, adgraf : dim f(nchars)
610 data 7, 1, 19, 64400
620 for i = 1 to nchars : read f(i) : next i
630 data -33, 1, 1, -34, 1, 1, -34, 1, 1, -34, 1, 1, -34, 1, 1,
    -34, 1, -32, 0
640 gosub 9600
670 input "Next?"; a$
680 print at 20,0; "Start tape for ""house"""
690 load "house" code
695 paper 7 : ink 0 : cls
699 paper 1: ink 3
700 print " B"
710 print "ACD"
715 paper 7 : ink 3
720 print "EFG"
730 print "HIJ"
740 print "KLM"
750 print "NOP"
760 print "QRC"
800 read lineno, colno, nchars, adgraf : dim f(nchars)
810 data 6, 1, 19, 64200
```

forgraf 3
1-10

```
820 for i =1 to nchars : read f(i) : next i
830 data 1,-2,-32,1,1,-34,1,1,-34,1,1,-34,1,1,
      -34,1,1,-33,0
840 gosub 9600
870 input "Next?";a$
880 print at 20,0;"Start tape for ""moor"""
890 load "moor" code
895 paper 7: ink 0: cls
900 print paper 1; ink 6; "ABC"
910 print paper 1; ink 6; "DEF"
950 read lineno, colno, nchars, adgraf :dim f(nchars)
960 data 1,1,6,64100
970 for i =1 to nchars : read f(i): next i
980 data 1,-32,-1,-1,32,0
990 gosub 9600
1070 input "Next?";a$
1080 paper 7; ink 0 : cls
1090 paper 7; ink 2
1100 print "MNL"
1110 print "HIG"
1120 print "KGG"
1200 read lineno, colno, nchars, adgraf : dim f(nchars)
1210 data 2,1,9,64000
1220 for i = 1 to nchars : read f(i) : next i
1230 data 1,-2,-32,1,1,-34,1,1,0
1240 gosub 9600
1270 input "Next?";a$
1280 paper 7 : ink 0 : cls
1300 print paper 1; ink 5; "JJJ"
1350 read lineno, colno, nchars, adgraf : dim f(nchars)
1360 data 0,1,3,63900
1370 for i =1 to nchars : read f(i) : next i
1380 data 1,-2,0
1390 gosub 9600
1400 STOP
```

AUTOGRAF (included in "forgraf")

```
9600  if lineno < 0 or lineno > 23 then goto 9650
9610  if colno < 0 or colno > 31 then goto 9660
9620  if nchars < 1 or nchars > 255 then goto 9670
[9630  if adgraf < peek(23730) + 256 * peek(23731)
       or adgraf > peek(23675) + 256 * peek(23676) - 10 * nchars
       then goto 9680 ]
9640  goto 9700
9650  print at 21,0; "Line no. error"; : stop
9660  print at 21,0; "Column no. error"; : stop
9670  print at 21,0; "Nchars error"; : stop
[9680  print at 21,0; "Adgraf error"; : stop ]

9700  let stgraf = adgraf : let adattr = 22528 + lineno * 32 + colno
9710  for i = 1 to nchars
9720      poke adgraf, peek adattr
9730      if adattr < 22784 then goto 9770
9740      if adattr < 23040 then goto 9760
9750      let addisp = adattr - 2560 : goto 9780
9760      let addisp = adattr - 4352 : goto 9780
9770      let addisp = adattr - 6144
9780      for j = 1 to 8 : let adgraf = adgraf + 1
9790          poke adgraf, peek addisp
9800          let addisp = addisp + 256
9810      next j
9820      let adgraf = adgraf + 1 : poke adgraf, f(i)
9830      let adgraf = adgraf + 1 : let adattr = adattr + f(i)
9840  next i
9850  print "Graphic stored at "; stgraf;
9860  return
```

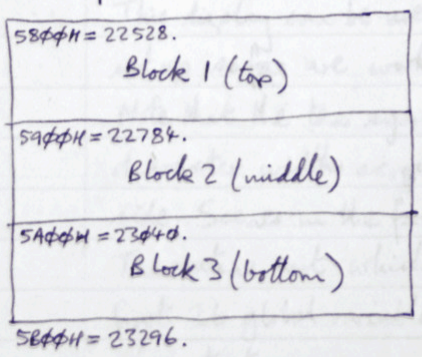
```
                        ; New GRAFPRINT
       ORG 65200        ; Position just below UDG. (User-Defined Graphics)
ADATT: DEFW 0           ; 65200 Pointer to display position in attr file
                        ; (22528..23295)
ADGRA: DEFW 0           ; 65202 Pointer to first byte of graphics string
GSHOW: LD   DE,(ADGRA)  ; 65204 Point to first byte of graphic
       LD   HL,(ADATT)  ; 65211 Point to display position in attr file
G0:    PUSH HL          ; Save attr file address
       LD   A,H         ; Look at MSB:
       CP   88          ; If < 88
       JR   C,OFFSC     ; then off top of screen
       CP   89          ; else if < 89
       JR   C,BLK1      ; then in top block of screen
       CP   90          ; else if < 90
       JR   C,BLK2      ; then in middle block of screen
       CP   91          ; else if >= 91
       JR   NC,OFFSC    ; then off bottom of screen
BLK3:  LD   BC,2560     ; Offset from bottom attr block to display file
       JR   COMMN       ; Join common path
BLK2:  LD   BC,4352     ; Offset from middle attr block to display file
       JR   COMMN       ; Join common path
BLK1:  LD   BC,6144     ; Offset from top attr block to display file
COMMN: LD   A,(DE)      ; Get 1st byte of character, the attribute code
       LD   (HL),A      ; Set attributes for this character
       AND  A           ; Clear carry
       SBC  HL,BC       ; Point to corresponding position in display file
       INC  DE          ; Point to first pixel byte this character
       LD   B,8         ; Count 8 pixel bytes
GLOOP: LD   A,(DE)      ; Get pixel byte and
       LD   (HL),A      ; display it
       DEC  BC          ; If 8 bytes done for this character
       JR   Z,EXITL     ; then exit loop
       INC  H           ; Point to next display byte this char, 256 forward
       INC  DE          ; Point to next pixel byte in character
       JR   GLOOP       ; Next pixel byte
OFFSC: LD   B,8         ; Off screen: loop to skip to 8th pixel this char
OLOOP: INC  DE
       DJNZ OLOOP
EXITL: POP  HL          ; Restore pointer to attr file
       INC  DE          ; Point to last byte this char, the offset to next
in attr file
       LD   A,(DE)      ; Get offset
       CP   0           ; If zero
       RET  Z           ; then end of string
       LD   B,0         ; Clear B
       CP   128         ; If offset < 0
       JR   C,POSOK
       DEC  B           ; then B = 255, ie extend sign for BC
POSOK: LD   C,A         ; BC = (signed) offset
       ADD  HL,BC       ; Add offset to attr file ptr to get new display posn
       INC  DE          ; Point to 1st byte of next character
       JR   G0          ; Do next character
```

Format of graphic string:

For each character:

Byte no.	Contents	
1	Attributes code	} Sinclair standard.
2..9	Pixel bytes, from top down	} Sinclair standard.
10	Offset in attr. file to next display position. Offset 0 means end of graphic.	

Addresses of screen blocks in attr. file:



Offsets to display file:

-1800H = -6144.

-1100H = -4352.

-0A00H = -2560.

Part 2 — Text string display and the title page, global data.

The next routine, textprint, displays a normal character string anywhere on screen (in the 32×24 character grid) given the starting address of the string and its required position in the attr. file. The character strings are held in memory as a sequence of ASCII bytes ending with zero (null).
The title page, displayed after The Forest has been loaded from tape shows examples of the terrain symbols (except 'grass', which is displayed differently) together with text strings for the title, copyright notice & a prompt for continuing.

Blank line for further copyright information if needed.

This display can be used to check that the graphics & display routines set up so far are working correctly.
Note that the ten symbols displayed occupy 30 of the available 32 character widths across the screen, leaving a margin of one at each side. Scenes in the forest will be displayed in the same way.
The routine init which displays the title page also initialises the first 26 global variables by block-moving values from a preset block of constants.

```
        ORG 63850     ; CLEAR SCREEN
SDF:    EQU 16384     ; Start of display file
SAF:    EQU 22528     ; Start of attribute file
ATTR0:  DEFB 0        ; Attributes byte for cleared screen: poke a value
ZERO:   DEFB 0        ; Value for display file
CLS:    LD BC,32*24   ; 24 lines to set in attr file
        LD DE,SAF     ; Destination for move
        LD HL,ATTR0   ; Source for move
        CALL CLOOP    ; Move
        LD BC,32*192  ; 192 lines to clear in display file
        LD DE,SDF     ; Destination for move
        LD HL,ZERO    ; Source for move
CLOOP:  LDI           ; Move
        DEC HL        ; Keep pointing to single source byte
        JP PE,CLOOP   ; Repeat until BC = 0
        RET


        ORG 63745     ; TEXTPRINT
ATTR:   DEFB 0        ; Attributes to be used for string
ADATT:  DEFW 0        ; Pointer to display position in attr file
ADTEX:  DEFW 0        ; Pointer to 1st byte of text string
TSHOW:  LD DE,(ADTEX) ; Point to string
        LD HL,(ADATT) ; Point to attr file
T0:     PUSH HL       ; Save attr file pointer
        LD A,H        ; Look at MSB
        CP 88         ; If < 88
        JR C,OFFSC    ; then off top of screen
        CP 89         ; else if < 89
        JR C,BLK1     ; then in top block
        CP 90         ; else if < 90
        JR C,BLK2     ; then in middle block
        CP 91         ; else if >= 91
        JR NC,OFFSC   ; then off bottom of screen
        LD BC,2560    ; Offset to display file, bottom block
        JR COMMN
BLK2:   LD BC,4352    ; Offset to display file, middle block
        JR COMMN
BLK1:   LD BC,6144    ; Offset to display file, top block
COMMN:  LD A,(DE)     ; Get ASCII byte from string
        CP 0          ; If null
        JR Z,ENDT     ; then end of string
        LD A,(ATTR)   ; Get attribute byte for string
        LD (HL),A     ; Set attributes for this character
        AND A         ; Clear carry
        SBC HL,BC     ; Offset pointer to display file
        PUSH DE       ; Save string pointer
        EX DE,HL      ; DE = display file pointer
        LD L,(HL)     ; Get ASCII code byte
        LD H,0        ; HL = ASCII code byte
        ADD HL,HL
        ADD HL,HL
```

```
       ADD HL,HL      ; HL = 8 * ASCII code byte
       LD BC,15360    ; Base addr of std char set in ROM (=15616 - 32 * 8)
       ADD HL,BC      ; HL points to 1st pixel byte in ROM for ASCII char
       LD B,8         ; Count 8 pixel bytes
TLOOP: LD A,(HL)      ; Get pixel byte
       LD (DE),A      ; Display it
       DEC B          ; If 8 bytes displayed
       JR Z,EXITL     ; then character done
       INC D          ; Point to next display file position this char, 256
forward
       INC HL         ; Point to next pixel byte
       JR TLOOP       ; Next byte
EXITL: POP DE         ; Restore string pointer
OFFSC: INC DE         ; Next char in string
       POP HL         ; Restore attr file pointer
       INC HL         ; Next attr file display position
       JR T0          ; Next character
ENDT:  POP HL         ; Tidy the stack
       RET

Format for stored text string: 1 byte ASCII code for each character
followed by zero byte to show end of string.

       ORG 63200      ; INIT (Title page & initialise global data)
T0:    EQU 63757
G0:    EQU 65210
CLS:   EQU 63852
ATTR0: EQU 63850
TATTR: EQU 63745
TITLE: DEFM "The Forest"
       DEFB 0
COPYR: DEFM "Copyright © Graham T Relf 1983  " ; 32 characters
DISTR: DEFS 32,32                    ; Spare line for distributor name
PKEY:  DEFM "Press any key to start"
       DEFB 0
INIT:  LD A,12        ; Paper blue, ink green
       LD (ATTR0),A
       CALL CLS
       LD A,15        ; Paper blue, ink white
       LD (TATTR),A
       LD DE,TITLE
       LD HL,23168    ; Line 20, column 0
       CALL T0
       LD DE,COPYR
       LD HL,23200    ; Line 21, column 0
       CALL T0        ; 3 lines just run on
       LD DE,64600                          ; GRUN
       LD HL,23138                          ; Line 18, column 2
       CALL G0                              ; Display tall tree
       LD DE,64400                          ; GFIR
       LD HL,23141                          ; Line 19, column 5
       CALL G0                              ; Display short tree
```

```
        LD DE,64400                             ; GFIR
        LD HL,23144                             ; Line 19, column 8
        CALL G0
        LD DE,64100                             ; GMOOR
        LD HL,23147                             ; Line 19, column11
        CALL G0                                 ; Display moor symbol
        LD DE,63900                             ; GLAKE
        LD HL,23182                             ; Line 20, column 14
        CALL G0
        LD DE,63900                             ; GLAKE
        LD HL,23185                             ; Line 20, column 17
        CALL G0
        LD DE,64200                             ; GTOWN
        LD HL,23156                             ; Line 19, column20
        CALL G0
        LD DE,64400                             ; GFIR
        LD HL,23159                             ; Line 19, column 23
        CALL G0
        LD DE,64000                             ; GFLAG
        LD HL,23162                             ; Line 19, column 26
        CALL G0
        LD DE,64600                             ; GRUN
        LD HL,23165                             ; Line 19, column 29
        CALL G0
        LD HL,CONST
        LD DE,VARS
        LD BC,NCONS
        LDIR                ; Set first NCONS variables to values in CONST
        RET
VARS:   DEFS 64
CONST:  DEFB 64             ; Initial values: bearing 90 degrees = 64b
        DEFB 0              ; sin b = 0
        DEFB 128            ; cos b = 1  (times 128)
        DEFB 0              ; Observer's start x = 1366.0
        DEFW 1366
        DEFB 0              ; Observer's start y = 2332.0
        DEFW 2332
        DEFS 12             ; 12 bytes do not need initialising
        DEFW 1438           ; x of finish
        DEFW 2272           ; y of finish
        DEFB 0              ; Clear the finished flag
NCONS:  EQU 26              ; 26 bytes to move for initialisation
        END
```

Terrain & feature names

The section of memory from 63600 to 63737 inclusive contains text strings for 'textprint' to display (ASCII characters followed by ϕ). These must be stored in the order given, which follows their numbering as terrain symbols & point feature names, ~~also~~ indexed elsewhere in the program.

The terrain types are

ϕ Run
1 Thick
2 Moor
3 Grass
4 Lake
5 Town

The point features are

ϕ Depression
1 Knoll
2 Niche
3 Boulder
4 Building
5 Ruin
6 Root␣stock
7 Sheep␣fold
8 Mine␣shaft
9 Rock␣outcrop
10 Pond
11 Water␣tank

vars 1
2-9

Layout of global variables (explanation – not coded).

		vars	equ	bear
F7C7	63431	bear	defb	; Bearing, ϕ..255
	63432	sinb	defb	; 128 * sin(bearing)
	3	cosb	defb	; 128 * cos(bearing)
	4	fxt	defb	; fractional
	5	lxt	defb	; low integer
	6	hxt	defb	; high integer
	7	fyt	defb	;
	8	lyt	defb	;
	9	hyt	defb	;
F7D0	63440	fxh	defb	;
	1	lxh	defb	;
	2	hxh	defb	;
	3	fyh	defb	;
	4	lyh	defb	;
	5	hyh	defb	;
	6	fhh	defb	;
	7	lhh	defb	;
	8	hhh	defb	;
	9	fhg	defb	;
	63450	lhg	defb	;
	1	hhg	defb	;
	2	xf	defw	; x-coordinate of finish (integer)
	4	yf	defw	; y- " " "
	6	finfl	defb	; Flag : 1 means we have reached the finish
	7	colum	defb	; Column no. for 'displa'
	8	tg	defb	; Terrain symbol at observer
	9	tersy	defb	; Terrain symbol on horizon
	63460	dbear	defb	; Bearing to horizon point, ϕ..255.
	1	sind	defb	; 128 * sin (dbear)
	2	cosd	defb	; 128 * cos (dbear)
	3	obsfl	defb	; Index to probability array for feature at observer.

63464	obsco	defb	Text string for flag code. 3rd byte always ϕ. 1st byte 32 ⇒ no flag.
5		defb	
6		defb	
7	spare	defs 3ϕ	

similar – observer's y-coordinate

similar – x-coordinate of terrain point to be evaluated

similar – y-coordinate " "

similar – result from height routine

similar – height at observer

2n : n = ϕ..5

continued above right.

Further notes on meaning of variables & their use.

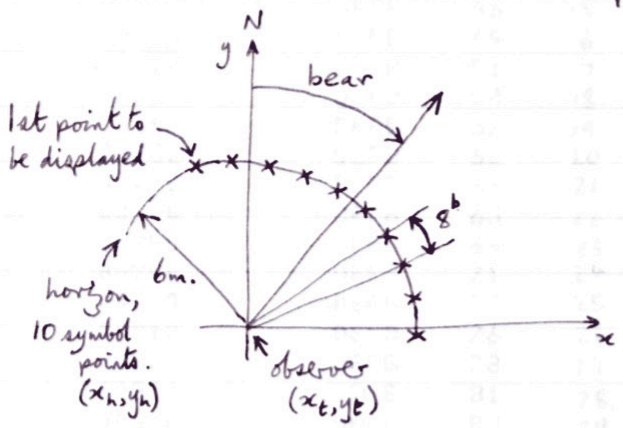
Bearings are measured in byte-sized degrees, range $\phi..255$. This gives adequate resolution for orienteers:

$256^b \equiv 360°$

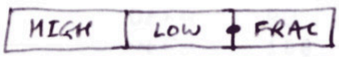
$64^b \equiv 90°$

$1^b \equiv 1°.40625$

$8^b \equiv 11°.25$ is the spacing between graphic symbols in a displayed scene:



Coordinates of observer and horizon points, and heights are stored as 3-byte fixed-point numbers, always in metres:



Arithmetic routines for such numbers are included in the program. Sines & cosines are looked up from a table, 'sintab', in which they are stored as signed integers in single bytes, as if multiplied by 128.

Part 3 – Sines & cosines (unchanged from TRS-80 version, except for addresses).

3-1

```
                00010 ; MODULE 3 OF <THE FOREST> : SIN & COS.
                00020 ; COPYRIGHT (C) GRAHAM T RELF 26/10/82.
                00030 ;
F654 ~~7770~~          00040          ORG     63060 ~~7770H~~
     ~~7770~~ 00       00050 SINTA    DEFB    0     ϕ^b
     7771 03           00060          DEFB    3     1
     7772 06           00070          DEFB    6     2
     7773 09           00080          DEFB    9     3
     7774 0C           00090          DEFB    12    4
     7775 10           00100          DEFB    16    5
     7776 13           00110          DEFB    19    6
     7777 16           00120          DEFB    22    7
     7778 19           00130          DEFB    25    8
     7779 1C           00140          DEFB    28    9
     777A 1F           00150          DEFB    31    10
     777B 22           00160          DEFB    34    11
     777C 25           00170          DEFB    37    12
     777D 28           00180          DEFB    40    13
     777E 2B           00190          DEFB    43    14
     777F 2E           00200          DEFB    46    15
     7780 31           00210          DEFB    49    16
     7781 33           00220          DEFB    51    17
     7782 36           00230          DEFB    54    18
     7783 39           00240          DEFB    57    19
     7784 3C           00250          DEFB    60    20
     7785 3F           00260          DEFB    63    21
     7786 41           00270          DEFB    65    22
     7787 44           00280          DEFB    68    23
     7788 47           00290          DEFB    71    24
     7789 49           00300          DEFB    73    25
     778A 4C           00310          DEFB    76    26
     778B 4E           00320          DEFB    78    27
     778C 51           00330          DEFB    81    28
     778D 53           00340          DEFB    83    29
     778E 55           00350          DEFB    85    30
     778F 58           00360          DEFB    88    31
     7790 5A           00370          DEFB    90    32
     7791 5C           00380          DEFB    92    33
     7792 5E           00390          DEFB    94    34
     7793 60           00400          DEFB    96    35
     7794 62           00410          DEFB    98    36
     7795 64           00420          DEFB    100   37
     7796 66           00430          DEFB    102   38
     7797 68           00440          DEFB    104   39
     7798 6A           00450          DEFB    106   40
     7799 6B           00460          DEFB    107   41
     779A 6D           00470          DEFB    109   42
     779B 6F           00480          DEFB    111   43
     779C 70           00490          DEFB    112   44
     779D 71           00500          DEFB    113   45
     779E 73           00510          DEFB    115   46
     779F 74           00520          DEFB    116   47
     77A0 75           00530          DEFB    117   48
     77A1 76           00540          DEFB    118   49
     77A2 78           00550          DEFB    120   50
     77A3 79           00560          DEFB    121   51
     77A4 7A           00570          DEFB    122   52
     77A5 7A           00580          DEFB    122   53
     77A6 7B           00590          DEFB    123   54
     77A7 7C           00600          DEFB    124   55
     77A8 7D           00610          DEFB    125   56
     77A9 7D           00620          DEFB    125   57
     77AA 7E           00630          DEFB    126   58
     77AB 7E           00640          DEFB    126   59
     77AC 7E           00650          DEFB    126   60
     77AD 7F           00660          DEFB    127   61
     77AE 7F           00670          DEFB    127   62
     77AF 7F           00680          DEFB    127   63
```

Table of 127 * sin (b)
: b = ϕ..64 b-degrees
(≡ ϕ..90°).

Quadrant 1.

Reading backwards gives cosines.

On entry to SINCOS,
A = bearing (0..255^b)

```
77AD 7F          00660 (previous  DEFB   127   64
77AE 7F          00670 page)      DEFB   127   63
77AF 7F          00680            DEFB   127   63
77B0 7F          00690 COSTA      DEFB   127   64
F695 77B1 010101 00700 SINCO      LD     BC,0101H
77B4 FEC0        00710            CP     192
77B6 3038        00720            JR     NC,QUAD4
77B8 FE80        00730            CP     128
77BA 302D        00740            JR     NC,QUAD3
77BC FE40        00750            CP     64
77BE 3021        00760            JR     NC,QUAD2
77C0 217077      00770 QUAD1      LD     HL,SINTA
77C3 1600        00780            LD     D,0
77C5 5F          00790            LD     E,A
77C6 19          00800            ADD    HL,DE
77C7 78          00810            LD     A,B
77C8 FEFF        00820            CP     -1
77CA 7E          00830            LD     A,(HL)
77CB 2002        00840            JR     NZ,POSSI
77CD ED44        00850            NEG
77CF 47          00860 POSSIN     LD     B,A
77D0 21B077      00870            LD     HL,COSTA
77D3 A7          00880            AND    A
77D4 ED52        00890            SBC    HL,DE
77D6 79          00900            LD     A,C
77D7 FEFF        00910            CP     -1
77D9 7E          00920            LD     A,(HL)
77DA 2002        00930            JR     NZ,POSCO
77DC ED44        00940            NEG
77DE 5F          00950 POSCO      LD     E,A
77DF 50          00960            LD     D,B
77E0 C9          00970            RET
77E1 ED44        00980 QUAD2      NEG
77E3 C680        00990            ADD    A,128
77E5 0EFF        01000            LD     C,-1
77E7 18D7        01010            JR     QUAD1
77E9 D680        01020 QUAD3      SUB    128
77EB 01FFFF      01030            LD     BC,0FFFFH
77EE 18D0        01040            JR     QUAD1
77F0 ED44        01050 QUAD4      NEG
77F2 06FF        01060            LD     B,-1
77F4 18CA        01070            JR     QUAD1
0000             01080            END
00000 TOTAL ERRORS
POSCOS  77DE
POSSIN  77CF
QUAD1   77C0
QUAD2   77E1
QUAD3   77E9
QUAD4   77F0
SINCOS  77B1
COSTAB  77B0
SINTAB  77Z0
```

On entry to SINCOS, A = bearing (0..255^b).

Signs of sin & cos for quadrant 1. Determine quadrant for A.

Point to start of table.

DE = bearing 'mod' quadrant

Sign of sin.

Get sin value (NB: flag not affected).

Complement sin.

Save sin in B.

Point to end of table.

Clear carry.

Offset pointer backwards (sin(90°-b) = cos(b))

Sign of cos.

Get cos value (NB: flag not affected).

Complement cos.

Return sin in D & cos in E.

2nd quadrant: sin(b) = sin(128-b) of quadrant

cos < ϕ.

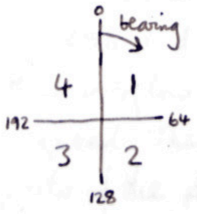
3rd quadrant: sin(b) = -sin(b-128) of quadrant 1.

sin < ϕ & cos < ϕ.

4th quadrant: sin(b) = -sin(256-b) of quadrant 1.

sin < ϕ.

Quadrants:



Signs:

SIN −	SIN +
COS +	COS +
SIN −	SIN +
COS −	COS −

Registers BC:

B	C
sign SIN	sign COS

(01 or FF)
+ −

All bearings are stored in 1 byte, as b-degrees:

$256^b = 360°$ Circle

$1^b = 1°.40625$ Minimum resolution: adequate for orienteering.

$64^b = 90°$

$8^b = 11°.25$ Angle between horizon points ('trees').

Part 4 – Height, terrain & feature generation (normal forest)

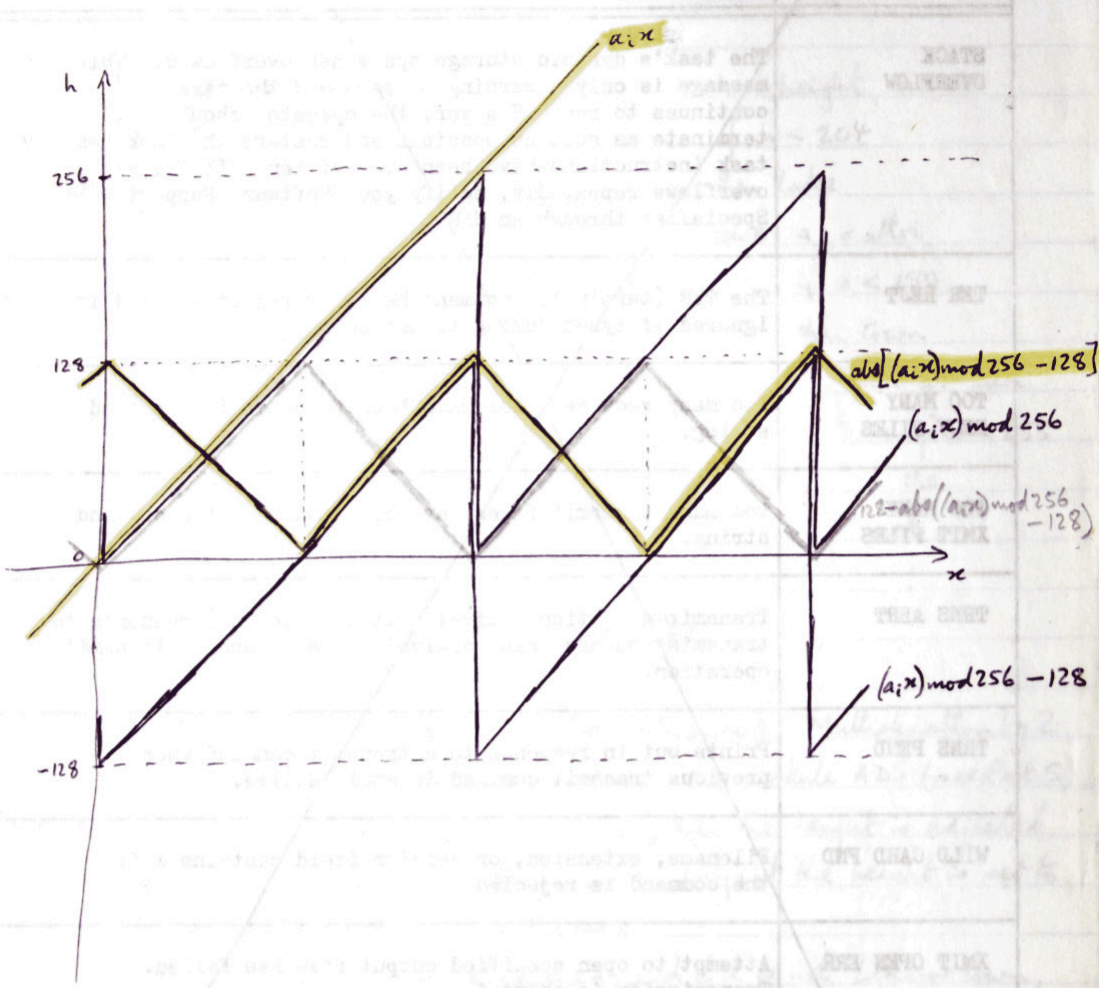
The height & other terrain attributes at any (x,y) point in the forest are calculated from functions, not stored as data. For an introduction to the philosophy behind this approach refer to my articles in 'Practical Computing', 5(3), March 82, pp. 93-95 and 5(9), Sept. 82, pp. 127–130.
The functions used in the 'normal' (simpler, fully mapped) forest are of the form

$$H = \sum_{i=1}^{5} \left[128 - \text{abs}\left((a_i x + b_i y) \bmod 256 - 128 \right) \right]$$

in which x, y are coordinates of the point being evaluated (3-byte fixed-point numbers),
a_i, b_i are single-byte integer coefficients, 5 of each forming a table of 10 bytes, the table being different for each attribute being evaluated (height being counted as one attribute).

The functions are evaluated by a machine code routine whose main entry point is 'heigh' and subsequent re-entries are at 'attri'. Register IX always points to the table of coefficients a_i & b_i and must not be altered between re-entries to 'attri'.
The operations involving 256 and 128 in the formula above are achieved by permitting overflow in multiplications and by doing complements, for speed. These operations are the most processor-dependent parts of the program.
The diagram on the next page indicates how a saw-tooth function is generated for one value of i in the above formula. As a function of both x & y this would result in a linear wave pattern normal to the line $y = a_i x + b_i$. By summing 5 such patterns oriented in different directions a suitably random effect is achieved.
The more complex forest is generated more elegantly – see part 8.

Height / terrain attribute function for The Forest



$$H = \sum_{i=1}^{5} [128 - abs((a_i x + b_i y) \bmod 256 - 128)]$$

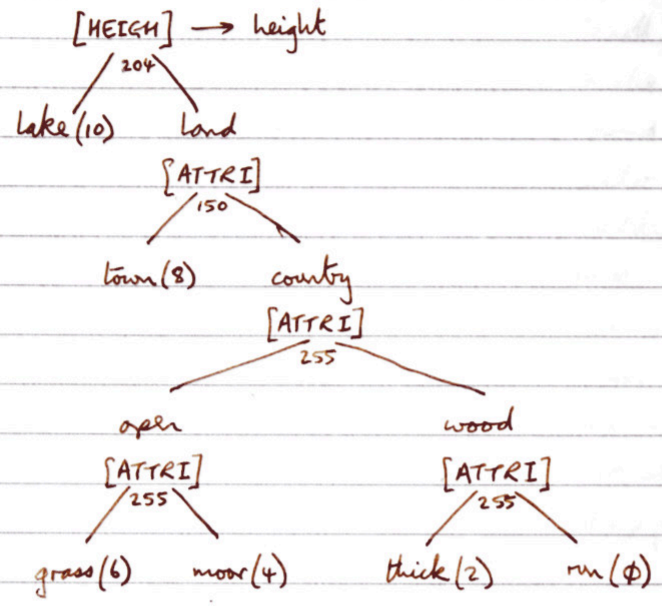
Initial values used in development:	i	1	2	3	4	5
	a_i	41	33	11	3	-13
	b_i	2	7	29	37	27

(-13 stored as 243)

General form:

$$H = \sum_{i} abs\left(\left(\sum_{j} a_{ij} x_j\right) \bmod K - \frac{K}{2}\right)$$

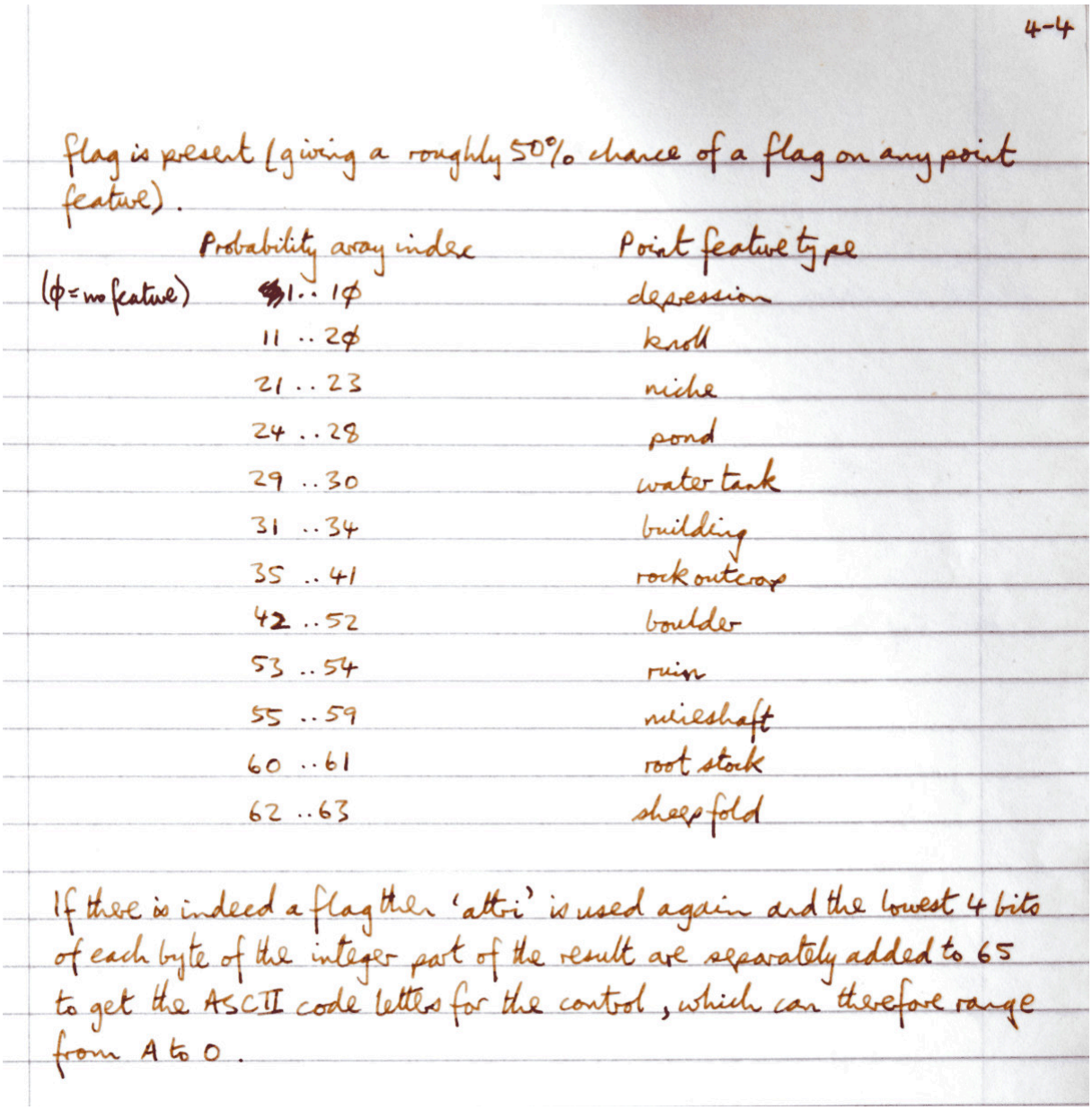
To determine the height and terrain type at any given point (x,y) the function may be evaluated up to 4 times, according to the following scheme.




```
h := height
if h < 204
then lake
else a := attri
     if a < 150
     then town
          else a := attri
               if a < 255
               then
               etc.
               :
```

Numbers in brackets are returned as 2 x (terrain type no.). Multiplication by 2 is to index a word-based table of addresses in the module ADS (see Part 5). Note that if a lake is detected (height < 204) then the height is adjusted so we cannot go below the surface of the lake. In fact the height is set to 200 to give a small bank around the lake.

When the terrain type has been established, and if it is not lake or town, then the routine 'featu' is used to determine whether there is a point feature visible. To do this the fractional parts and the lowest 3 bits of the integer parts of the coordinates (x, y) of the point being tested are cleared to 0. This ensures that point features are visible within 8x8 squares. The 'attri' routine is used yet again, this time with IX pointing half-way through one of the previously used tables of coefficients (a_i, b_i). If the result this time has bit 7 set but not bits 0, 1, 2 or 4 then a point feature is present. If this is the case 'attri' is used again, with IX continuing from its last position, bits 0 to 5 index an array of probabilities of the different types of feature, as in the following table, while bit 6 determines whether a control



4-4

flag is present (giving a roughly 50% chance of a flag on any point feature).

(ϕ=no feature)	Probability array index	Point feature type
	01..1ϕ	depression
	11..2ϕ	knoll
	21..23	niche
	24..28	pond
	29..30	water tank
	31..34	building
	35..41	rock outcrop
	42..52	boulder
	53..54	ruin
	55..59	mineshaft
	60..61	root stock
	62..63	sheep fold

If there is indeed a flag then 'attri' is used again and the lowest 4 bits of each byte of the integer part of the result are separately added to 65 to get the ASCII code letters for the control, which can therefore range from A to O.

See later for details of how the terrain generator is modified for the improved "Complex Forest".

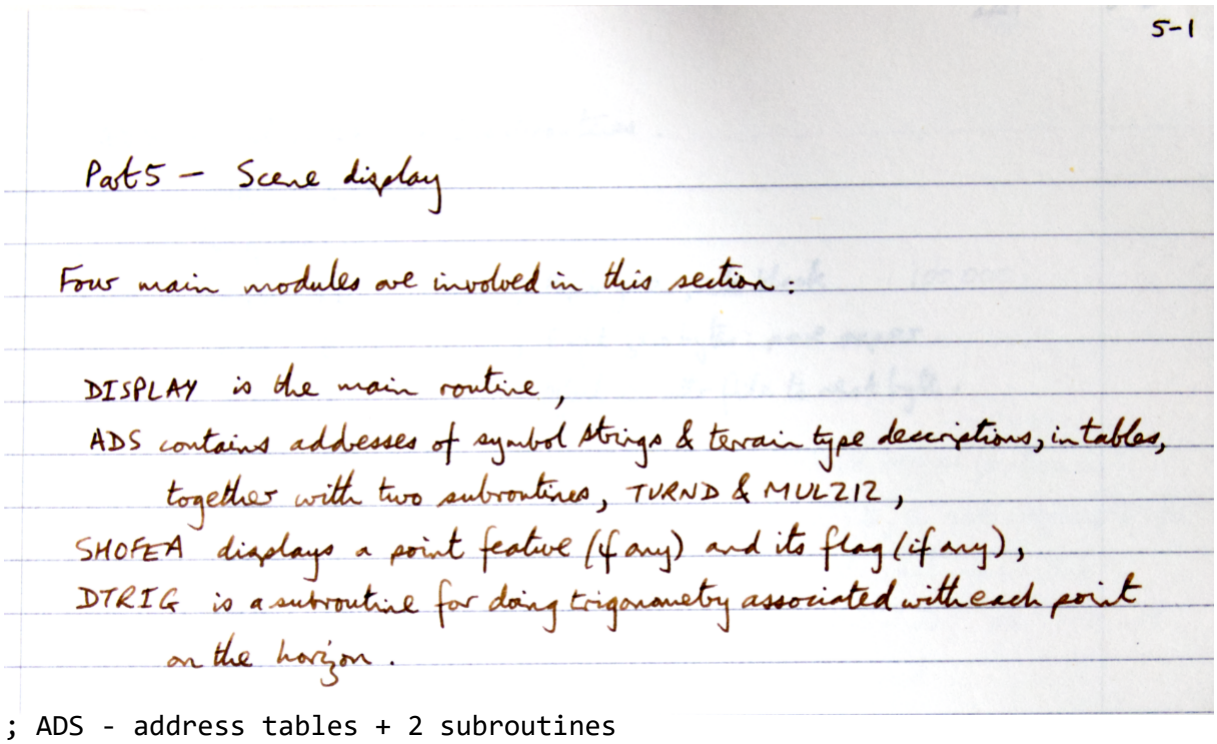
```
        ORG 62580     ;TERRA - the original terrain generator
FXH:    EQU 63440
LXH:    EQU FXH + 1
HXH:    EQU FXH + 2
FYH:    EQU FXH + 3
LYH:    EQU FXH + 4
HYH:    EQU FXH + 5
FHH:    EQU FXH + 6
LHH:    EQU FXH + 7
HHH:    EQU FXH + 8
TG:     EQU FXH + 18
TERSY:  EQU FXH + 19
TERRA:  CALL HEIGH
        LD A,(FH)
        LD (FHH),A
        LD HL,(LH)
        LD (LHH),HL
        LD A,H
        CP 0
        JR NZ,LAND
        LD A,L
        CP 204        ;Lake height + bank
        JR C,TLAKE    ;Lake here
LAND:   XOR A         ;A = 0
        LD (FXH),A    ;Attributes to constant
        LD (FYH),A    ;over 1m cells
        CALL ATTRI    ;NB: HEIGH left IX pointing to TABA1
        LD A,(HH)
        CP 0
        JR NZ,CNTRY
        LD A,(LH)
        CP 150
        JR C, TTOWN   ;Town here
CNTRY:  CALL ATTRI    ;NB: Last ATTRI left IX pointing to TABA2
        LD A,(HH)
        CP 0
        JR NZ,WOOD
        LD A,(LH)
        CP 255
        JR C,OPEN
WOOD:   CALL ATTRI    ;NB: Last ATTRI left IX pointing to TABA3
        LD A,(HH)
        CP 0
        JR NZ,TRUN    ;Runnable wood here
        LD A,(LH)
        CP 255
        JR C,THICK    ;Thicket here
TRUN:   LD A,0
        LD (TERSY),A
        JP FEATU
THICK:  LD A,2
        LD (TERSY),A
        JP FEATU
```

```
OPEN:  CALL ATTRI    ;NB: Last ATTRI left IX pointing to TABA3
       LD A,(HH)
       CP 0
       JR NZ,TMOOR   ;Moor here
       LD A,(LH)
       CP 255
       JR C,TGRAS
TMOOR: LD A,4
       LD (TERSY),A
       JP FEATU
TGRAS: LD A,6
       LD (TERSY),A
       JP FEATU
TTOWN: LD A,8
       LD (TERSY),A
       JP FEATU
TLAKE: LD A,200      ;Set lake level so we cannot
       LD (LHH),A
       XOR A
       LD (FHH),A
       LD A,10
       LD (TERSY),A
       JP FEATU
;Height & attributes function:
HEIGH: LD IX,ABH     ;Point to table of height coefficients
ATTRI: XOR A         ;A = 0
       LD (FH),A     ;Initialise
       LD (LH),A     ;the
       LD (HH),A     ;sum.
       LD B,5        ;No of coeff pairs in table
HLOO1: PUSH BC       ;Save loop counter i
       LD DE,(LXH)   ;Get
       LD A,(FXH)    ;x-coordinate
       LD B,A
       CALL MULCO    ;HL.A = a[i]*x, point IX to b[i]
       PUSH HL
       PUSH AF
       LD DE,(LYH)   ;Get
       LD A,(FYH)    ;y-coordinate
       LD B,A
       CALL MULCO    ;HL.A = b[i] * y, point IX to a[i+1]
       POP BC
       POP DE        ;DE.B = a[i] * x
       ADD A,B
       ADC HL,DE     ;HL.A = a[i]x + b[i]y
NORM1: LD D,L
       LD E,A        ;D.E = result mod 256
       LD A,D        ;MSB
       CP 127        ;If in right half of triangle
       JR C,REPOS
       LD A,E        ;then fold over (ie, negate D.E)
       CPL
       ADD A,1
```

```
        LD E,A
        LD A,D
        CPL
        ADC A,0
        LD D,A          ;D.E = 256 - D.E
REPOS:  LD HL,(FH)      ;Add into overall sum in FH,LH,HH
        ADD HL,DE
        LD (FH),HL
        LD A,(HH)
        ADC A,0
        LD (HH),A
        POP BC          ;Retrieve loop counter, i
        DJNZ HLOO1      ;Next i
        RET
;Multiply coord DE.B by signed coeff pointed by IX
;Result in HL.A
MULCO:  XOR A           ;A = 0
        LD H,A
        LD L, A
        LD C,(IX+0)     ;Get coeff a[i] or b[i]
        BIT 7,C         ;Sign?
        JR NZ,SUBCO
        CALL ADDBT
        CALL ADDBT
        CALL ADDBT
        CALL ADDBT
        CALL ADDBT
        CALL ADDBT
        CALL ADDBT      ;7 times
ENDCO:  RR H
        RR L
        RRA
        INC IX          ;Point to next coeff, b[i] or a[i+1]
        RET
SUBCO:  CALL SUBBT
        CALL SUBBT
        CALL SUBBT
        CALL SUBBT
        CALL SUBBT
        CALL SUBBT
        CALL SUBBT      ;7 times
        JR ENDCO
ADDBT:  RR H
        RR L
        RRA
        RR C
        RET NC
        ADD A,B
        ADC HL,DE
        RET
SUBBT:  RR H
        RR L
        RRA
```

```
        RR C
        RET NC
        SUB B
        SBC HL,DE
        RET
;Point features, flags & codes
FEATY: DEFB 0        ;Index to 1..63 array of probabilities of
;each feature type (0..11)
CODE:  DEFB 32       ;2-letter flag code,
        DEFB 32      ;spaces if no flag
        DEFB 0
FEATU: LD A,(TERSY)  ;Get observer's terrain type
        CP 7
        JR NC,NOFEA  ;No features in lake or town
        LD IX,TABA1-5 ;Re-use existing coeff tables
        XOR A        ;A = 0
        LD (FXH),A   ;Features to be visible in 8x8m area:
        LD (FYH),A
        LD A,(LXH)
        AND 0F8H
        LD (LXH),A
        LD A,(LYH)
        AND 0F8H
        LD (LYH),A
        CALL ATTRI   ;Results in FH,LH,HH
        LD A,(LH)    ;NB: FH = 0 so can't use that
        AND 097H     ;10010111
        CP 128
        JR NZ,NOFEA
        CALL ATTRI   ;NB: Last ATTRI left IX at TABA2-5
        LD A,(LH)
        AND 63       ;Indexing 1..63 array
        LD (FEATY),A
        LD A,(LH)
        AND 64
        JR Z,NOCOD   ;1 in 2 chance of a flag
        CALL ATTRI   ;NB: Last ATTRI left IX at TABA3-5
        LD A,(HH)
        AND 15       ;Range A..O [in practice A..C]
        ADD A,65     ;To ASCII letter
        LD (CODE),A
        LD A,(LH)
        AND 15       ;Range A..O
        ADD A,65
        LD (CODE+1),A
        RET
NOFEA: XOR A         ;A = 0
        LD (FEATY),A
NOCOD: LD A,32
        LD (CODE),A
        LD (CODE+1),A
        RET
;Local data:
```

```
FH:     DEFB 0
LH:     DEFB 0
HH:     DEFB 0
;Tables of coefficients:
ABH:    DEFB 200        ;a1
        DEFB 3          ;b1
        DEFB 165        ;a2
        DEFB 37         ;b2
        DEFB 127        ;a3
        DEFB 96         ;b3
        DEFB 101        ;a4
        DEFB 202        ;b4
        DEFB 13         ;a5
        DEFB 157        ;b5
TABA1:  DEFB 171
        DEFB 131
        DEFB 171
        DEFB 140
        DEFB 184
        DEFB 106
        DEFB 97
        DEFB 126
        DEFB 124
        DEFB 96
TABA2:  DEFB 152
        DEFB 107
        DEFB 153
        DEFB 182
        DEFB 68
        DEFB 162
        DEFB 118
        DEFB 179
        DEFB 158
        DEFB 171
TABA3:  DEFB 179
        DEFB 172
        DEFB 190
        DEFB 108
        DEFB 186
        DEFB 101
        DEFB 192
        DEFB 192
        DEFB 95
TABAD:  DEFB 172
        END
```



5-1

Part 5 – Scene display

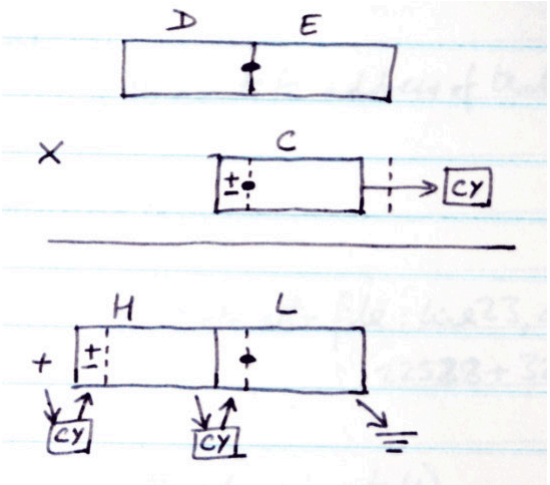
Four main modules are involved in this section:

DISPLAY is the main routine,
ADS contains addresses of symbol strings & terrain type descriptions, in tables, together with two subroutines, TURND & MULZ12,
SHOFEA displays a point feature (if any) and its flag (if any),
DTRIG is a subroutine for doing trigonometry associated with each point on the horizon.

```
; ADS - address tables + 2 subroutines
        ORG 62350
; Graphic for grass:
GRASS:  DEFB 32     ; Paper green, ink black
        DEFS 8      ; 8 zero bytes - pure paper
        DEFB 1      ; Offset in attr file to next byte
        DEFB 32
        DEFS 8
        DEFB 1
        DEFB 32
        DEFS 8
        DEFB 0
; The next 2  tables are indexed by 2t, where t = terrain type, 0..5
ADSYM:  DEFW 64600  ; Table of graphics
        DEFW 64400
        DEFW 64100
        DEFW GRASS
        DEFW 64200
        DEFW 63900
ADOBS:  DEFW 63600  ; Table of terrain messages
        DEFW 63604
        DEFW 63610
        DEFW 63615
        DEFW 63626
        DEFW 63621

BEAR:   EQU 63431
SINB:   EQU 63432
SINCO:  EQU 63125
TURND:  LD A,(BEAR) ; Compute & store sin & cos of new bearing
        CALL SINCO  ; after a turn
        LD HL,SINB
        LD (HL),D
```

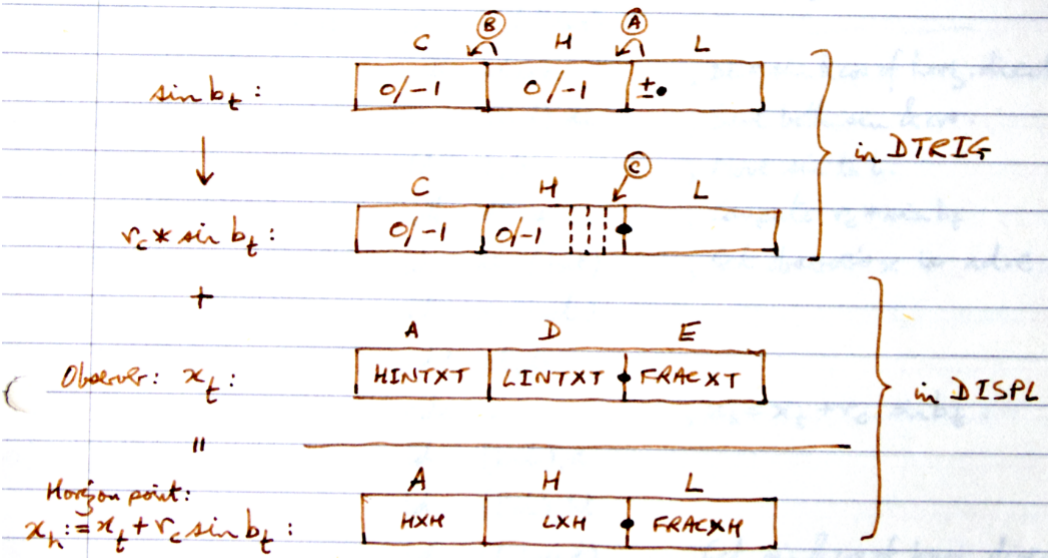
```
        INC HL
        LD (HL),E
        RET
; Multiply +ve 2-byte fixed-point no in D.E by 1-byte signed fraction in C
; [+/- .7 bits], to get signed 2-byte fixed-point in H.L [+/- 7Bits.byte].
; NB: D.E not changed
MUL212: LD A,1      ; Sign +ve until otherwise
        BIT 7,C     ; If sign(C) < 0
        JR Z,POS212
        LD A,C      ; then
        NEG         ; complement and
        LD C,A      ; set -ve sign
        LD A,255    ; for result
POS212: LD B,7      ; 7 bits left in C to shift & add
        LD HL,0
        AND A       ; Clear carry
LO212:  RR H
        RR L
        OR C
        JR NC,EN212 ; If bit set at right of C
        ADD HL,DE   ; then add DE into result. NB: Carry affected
EN212:  DJNZ LO212  ; NB: Loop test preserves carry
        RR H        ; Shift to put any
        RR L        ; carry into result
        CP 255      ; If sign (in A) +ve
        RET NZ      ; then done
NEG2:   LD A,L      ; else take
        CPL         ; twos complement
        ADD A,1     ; of result
        LD L,A
        LD A,H
        CPL
        CPL
        ADC A,0
        LD H,A
        AND 80H     ; Select bit 7 (sign)
        RLCA
        NEG
        LD B,A      ; HL >= 0 => B = 0 else B = -1
        RET
        END
; NEG2 may be used as general subroutine
; to complement HL
```



```
; SHOFEA - show point feature & flag
        ORG 62495
T0:     EQU 63757
SHOFE:  LD HL,FIN1
        LD B,12         ; 12 feature types, counter
SHLOO:  CP (HL)         ; If feature index in A > table entry
        JR C,INC2       ; then this is the feature type
        INC HL
        INC HL          ; Word-based table => 2 increments
        DJNZ SHLOO
        RET
INC2:   LD DE,FIN2-FIN1
        ADD HL,DE       ; HL points to address of text string
        LD E,(HL)
        INC HL
        LD D,(HL)
        LD HL,23283     ; Point to attr file, line 23, column 19:
        CALL T0         ; 22528 + 32 * 23 + 19
        RET
; Index1: probability table for point features (see part 4)
FIN1:   DEFW 11
        DEFW 21
        DEFW 24
        DEFW 29
        DEFW 31
        DEFW 35
        DEFW 42
        DEFW 53
        DEFW 55
        DEFW 60
        DEFW 62
        DEFW 64
; Index 2: string addresses
FIN2:   DEFW 63631      ; "Depression"
        DEFW 63642      ; "Knoll"
        DEFW 63648      ; "Niche"
        DEFW 63722      ; "Pond"
        DEFW 63727      ; "Water tank"
        DEFW 63662      ; "Building"
        DEFW 63709      ; "Rock outcrop"
        DEFW 63654      ; "Boulder"
        DEFW 63671      ; "Ruin"
        DEFW 63698      ; "Mine shaft"
        DEFW 63676      ; "Root stock"
        DEFW 63687      ; "Sheep fold"
        END
```

DTRIG – Subroutine to compute $r_c * \{\sin / \cos\}$ (horizon point direction).
↑ (in separate calls).

```
        org   62480
dtrig   ld    h,0
        bit   7,l        ; (A)
        jr    z,dpos
        ld    h,255
dpos    ld    c,h        ; (B)
        ld    b,4        ; r_c = 8 = 2^(4-1)
dloo2   add   hl,hl      ; (C) HL := r_c * sin b_t
        djnz  dloo2
        ret
        end
```



Similarly for $\cos b_t$, y_t, y_h in DISPL.

```
        ORG 62050     ; DISPL - display current scene
CHLIN:  DEFB 0
SCLIN:  DEFB 0
TURN:   CALL TURND
DISPL:  LD A,12       ; Paper blue, ink green
        LD (ATTR0),A
        CALL CLS      ; Clear screen
        LD A,2        ; 1st col to display (tree can overhang col 1)
        LD (COLUM),A
        LD A,(BEAR)   ; Get straight-ahead bearing
        SUB 36        ; Look 4.5 symbol spaces left
        LD (DBEAR),A
DLOO1:  LD A,(DBEAR)
        CALL SINCO    ; DE = sin & cos of horizon direction
        LD (SIND),DE  ; Save both sin & cos
        LD L,D        ; Move sin to L
        CALL DTRIG    ; Compute rc * sin bt
        LD DE,(FXT)   ; Get observer's x in AD.E
        LD A,(HXT)
        ADD HL,DE
        ADC A,C       ; xh = xt + rc * sin bt
        LD (HXH),A    ; Horizon position
        LD (FXH),HL
        LD HL,(SIND)  ; Get sin & cos of horizon direction
        CALL DTRIG    ; Compute rc * cos bt
        LD DE,(FYT)   ; Get observer's y in AD.E
        LD A,(HYT)
        ADD HL,DE
        ADC A,C
        LD (HYH),A
        LD (FYH),HL
        CALL TERRA    ; Get height, terrain, feature for horizon point
        LD A,(FHH)
        LD C,A
        LD A,(FHG)
        SUB C
        LD HL,(LHG)
        LD DE,(LHH)
        SBC HL,DE     ; HL.A = (hg-hh)*sh = ht difference, sh = 1 => range -
23..24
        LD BC,24
        ADD HL,BC     ; HL.A += 24, range 0..47
        LD H,L
        LD L,A        ; H.L = ht diff, range 47..0
        LD A,H
        SRL A         ; A = ht diff, range 23..0
        LD (CHLIN),A  ; Character-sized position
        XOR A         ; A = 0
        LD (HFLAG),A  ; No flag until shown otherwise
        LD A,(CODE)
        CP 32         ; Is flag visible from horizon point?
        JR Z, NFLAG
        LD A,(OBSCO)
```

```
        CP 32           ; Has observer got a flag too?
        JR NZ,NFLAG
        LD A,1
        LD (HFLAG),A    ; Horizon flag to be shown
NFLAG:  LD A,(TERSY)    ; Get terrain type (x 2)
        LD C,A
        LD B,0          ; BC = word offset from ADSYM, graphics table
        LD HL,ADSYM
        ADD HL,BC
        LD E,(HL)
        INC HL
        LD D,(HL)       ; DE points to graphic
        LD A,(CHLIN)    ; A = row, 0..23
        LD H,0
        LD L,A          ; HL = row, 0..23
        ADD HL,HL       ; x 32:
        ADD HL,HL
        ADD HL,HL
        ADD HL,HL
        ADD HL,HL       ; HL = 32 * row
        LD A,(COLUM)
        LD B,0
        LD C,A          ; BC = column
        ADD HL,BC       ; HL = 32 * row + column
        LD BC,22528     ; Start of attributes file
        ADD HL,BC       ; HL points to row & col in attr file
        LD A,(TERSY)    ; Terrain symbol
        CP 6            ; Grass => no graphic
        JR Z,NG0
        PUSH HL
        CALL G0         ; Display graphic
        POP HL
        LD A,(TERSY)
        CP 10           ; Lake => no flag on horizon nor ground bar
        JR Z,NGRAF
NG0:    LD DE,31
        ADD HL,DE       ; HL points to start of ground (grass) in attr file
        LD DE,62350     ; DE points to grass in ADS
        CALL G0         ; Display grass
        LD A,(HFLAG)
        CP 0            ; No horizon flag => no more on this horizon point
        JR NZ,NGRAF
        LD DE,34
        AND A
        SBC HL,DE       ; HL points to horizon flag position
        LD A,H
        CP 91           ; If off screen don't show it
        JR NC,NGRAF
        LD (HL),3BH     ; Paper white, ink magenta
NGRAF:  LD A,(COLUM)    ; Get column
        CP 28           ; If > 28, all done
        JR NC,ENDIS
        ADD A,3         ; Else next column
```

```
        LD (COLUM),A
        LD A,(DBEAR)
        ADD A,8         ; Next horizon point bearing
        LD (DBEAR),A
        JP DLOO1        ; Next horizon point (loop)
ENDIS:  LD HL,22895     ; Line 11, column 15 = centre of screen
        SET 7,(HL)      ; Flash = level marker
        LD A,(TG)       ; Get observer's terrain type (x 2)
        LD HL,ADOBS     ; Offset pointer from ADOBS, message table
        LD C,A
        LD D,0
        ADD HL,DE
        LD E,(HL)
        INC HL
        LD D,(HL)       ; DE points to message string
        LD HL,23264     ; Display at line 23 column 0
        CALL T0         ; Display observer's terrain message
        LD A,(OBSFE)
        CP 0            ; If no feature at observer, then done
        JR Z,ENDAL
        CALL SHOFE      ; Show feature
        LD HL,(OBSCO)
        LD A,32
        CP H            ; If no flag at observer, then done
        JR Z,ENDAL
        LD DE,64000     ; Point to graphic for flag
        LD HL,23279     ; Line 23 column 15
        CALL G0         ; Display flag
ENDAL:  RET
HFLAG:  DEFB 0          ; Whether flag is visible from horizon point
        END



        ORG 62040  ; HIGH - returns int (height) for test purposes
HEIGH:  EQU 62737
LH:     EQU 63011
HIGH:   CALL HEIGH
        LD BC,(LH)
        RET
        END
```

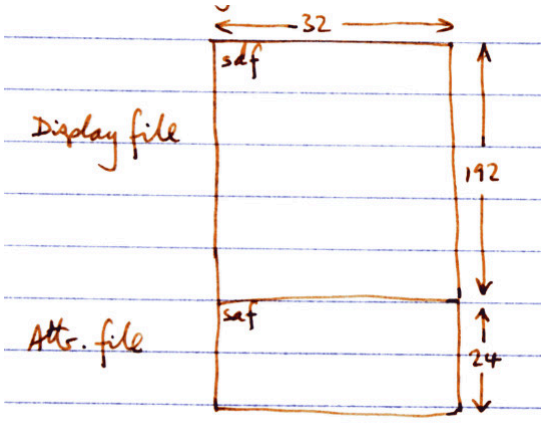
Part 6 - Turning and moving forward

Two modules:

SCROLLS - move screen left and right in character sized steps (not pixel sized because colours would go funny; colours are in the attributes file which is character based).

MOVE - moves the observer forward one pace (about 1m +/- 10%) and drifts the bearing by up to +/- 1 b-degree.

In scrolling we have to move both the display file and the attributes file. The display files is moved first, to minimise the period when the colours might be wrong.

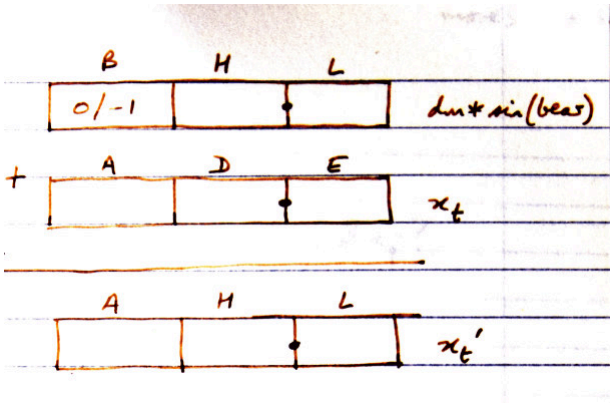



```
        ORG 61700       ; SCROLLS - left & right scrolling (panning)
TURN:   EQU 62052
ATTR0:  EQU 63850
BEAR:   EQU 63431
RIGHT:  LD A,(BEAR)     ; Turn right 8 b-degrees
        ADD A,8
        LD (BEAR),A
        LD B,3          ; Scroll left 3 times = 1 symbol space
LEFLO:  PUSH BC
        CALL SCLEF
        POP BC
        DJNZ LEFLO
        JP TURN
LEFT:   LD A,(BEAR)     ; Turn left 8 b-degrees
        SUB 8
        LD (BEAR),A
        LD B,3          ; Scroll right 3 times
RIGLO:  PUSH BC
        CALL SCRIG
        POP BC
        DJNZ RIGLO
        JP TURN
BACK:   LD A,(BEAR)     ; Half turn, 128 b-degrees
        ADD A,128
        LD (BEAR),A
```

```
       LD B,30        ; Scroll left 30 times
       JR LEFLO
; Start addresses of display & attr files:
SDF:   EQU 16384
SAF:   EQU 22528
; Scroll left by 1 character:
SCLEF: LD HL,SDF
       CALL CLCOL     ; Clear left column
       LD BC,6143     ; Bytes to move
       LD DE,SDF      ; Destination
       LD HL,SDF+1    ; Source
       LDIR           ; Move display file
       LD BC,767
       LD DE,SAF
       LD HL,SAF+1
       LDIR           ; Move attr file
       RET
; Scroll right by 1 character:
SCRIG: LD HL,SDF+31
       CALL CLCOL     ; Clear right column
       LD BC,6143
       LD DE,SDF+6143
       LD HL,SDF+6142
       LDDR           ; Move display file
       LD BC,767
       LD DE,SAF+767
       LD HL,SDF+766
       LDDR           ; Move attr file
       RET
; Clear column whose top is pointed to by HL:
CLCOL: LD B,192
       LD DE,32
CL1:   LD (HL),0      ; Zero display file (paper everywhere!)
       ADD HL,DE
       DJNZ CL1
       LD A,(ATTR0)   ; (Might depend on whether colour TV?)
       LD B,24
CL2:   LD (HL),A      ; Reset attributes in attr file
       ADD HL,DE
       DJNZ CL2
       RET
       END
```

```
        ORG 61850     ; MOVE - move observer forward and drift
BEAR:   EQU 63431
TURND:  EQU 62404
MUL212: EQU 62417
TERRA:  EQU 62580
SINB:   EQU 63432
COSB:   EQU 63433
FXT:    EQU 63434
LXT:    EQU 63435
HXT:    EQU 63436
FYT:    EQU 63437
LYT:    EQU 63438
HYT:    EQU 63439
FXH:    EQU 63440
LXH:    EQU 63441
HXH:    EQU 63442
FYH:    EQU 63443
LYH:    EQU 63444
HYH:    EQU 63445
FHH:    EQU 63446
LHH:    EQU 63447
HHH:    EQU 63448
FHG:    EQU 63449
LHG:    EQU 63450
HHG:    EQU 63451
XF:     EQU 63452
YF:     EQU 63454
FINFL:  EQU 63456
TG:     EQU 63458
TERSY:  EQU 63459
FEATY:  EQU 62905
OBSFE:  EQU 63463
CODE:   EQU 62906
OBSCO:  EQU 63464
DISPL:  EQU 62055
MOVE:   LD A,R        ; Get random byte from Z80 refresh register
        LD C,A        ; treat as fraction to be multiplied by 0.1
        LD D,0
        PUSH DE       ; Save fraction while bearing drifts
        LD A,(BEAR)
        BIT 5,C
        JR Z,NPLUS
        ADD A,1       ; Inc bearing by 1 b-degree
NPLUS:  BIT 3,C
        JR Z,NOMIN
        SUB 1         ; Dec bearing by 1 b-degree
NOMIN:  LD (BEAR),A
        CALL TURND    ; Revise sin & cos
        POP DE        ; Retrieve random fraction
        LD C,1AH      ; C = 0.1
        CALL MUL212   ; HL = random part of distance to move
        LD DE,0E6H    ; DE = fixed part of same = 0.9
        ADD HL,DE     ; HL = distance to move
```

```
        PUSH HL         ; Save for incrementing yt
        EX DE,HL        ; Move to DE for incrementing xt
        LD A,(SINB)     ; sin(BEAR)
        LD C,A
        CALL MUL212     ; HL = sinb * distance to move
        LD DE,(FXT)     ; Adding to xt : get fractional & low parts of xt
        LD A,(HXT)      ; Get high part of xt
        ADD HL,DE
        ADC A,B         ; Use sign byte from LU"!" result above
        LD (FXT),HL     ; xt = xt + move * sinb
        LD (FXH),HL     ; New xt will be used to find obeserver's height
        LD (HXT),A
        LD (HXH),A
; Similarly for yt:
        POP DE
        LD A,(COSB)
        LD C,A
        CALL MUL212
        LD DE,(FYT)
        LD A,(HYT)
        ADD HL,DE
        ADC A,B
        LD (FYT),HL
        LD (FYH),HL
        LD (HYT),A
        LD (HYH),A
        LD HL,YF+1      ; Test for finish:
        CP (HL)         ; Do MSBs of yt & yf match?
        JR NZ,HMOVE
        LD A,(LYT)
        AND 0FCH
        LD B,A
        DEC HL
        LD A,(HL)
        AND 0FCH
        CP B            ; And LSBs, within 4 metres?
        JR NZ,HMOVE
        DEC HL
        LD A,(HXT)
        CP (HL)         ; And MSBs of xt and xf?
        JR NZ,HMOVE
        LD A,(LXT)
        AND 0FCH
        LD B,A
        DEC HL
        LD A,(HL)
        AND 0FCH
        CP B
        JR NZ,HMOVE     ; And LSBs within 4 metres?
        LD A,1          ; If all matched we are at finish
        LD (FINFL),A    ; Set flag for BASIC shell to test
HMOVE:  CALL TERRA      ; Get observer's height and terrain
        LD A,(FHH)      ; Save height in HG
```

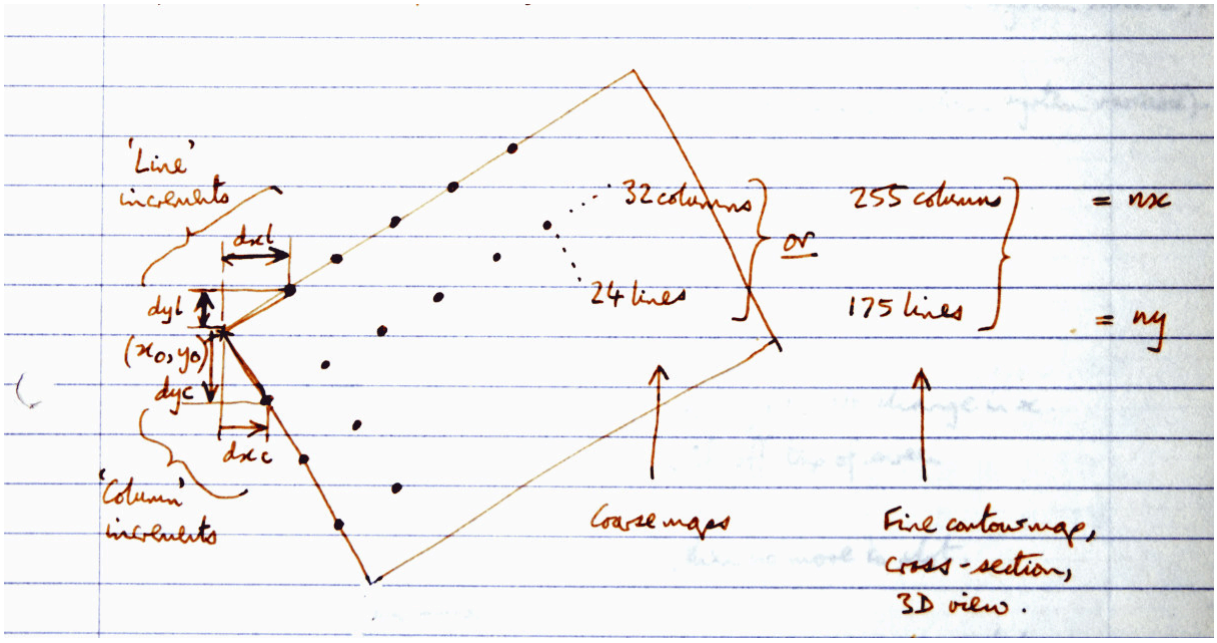


```
LD (FHG),A
LD HL,(LHH)
LD (LHG),HL
LD A,(TERSY)  ; Save terrain type in TG
LD (TG),A
LD A,(FEATY)  ; Save feature type
LD (OBSFE),A
LD HL,(CODE)  ; Save flag code
LD (OBSCO),HL
JP DISPL
```

Part 7 - Maps

The first routine in this section, DRAWFN, is a subroutine for plotting or unplotting points in a vertical line according to a binary pattern held in array BAR. This is used to draw contoured cross-sections and 3D views (which are essentially repeated cross-sections).

Maps are drawn by calling a standard harness (entry FHEAD) having first poked the address of a kernel routine into MADDR from the BASIC shell. Different types of map are produced by different kernels. The kernel determines the map content for a particular point (x, y), while the harness scans a rectangular area, the definition of which has been poked from the BASIC shell:



x_0, y_0 is top left, to draw the map in normal reading order, not bottom left as set up by the user in the BASIC shell.

A cross-section is actually done by using the VIEW3D kernel with ny = 1 (ie, just 1 line to draw).

```
        ORG 61500       ; DRAWFN subroutine
PLOT:   EQU 22E5H       ; Spectrum Rom routine. Enter with B = y, C = x
BAR:    DEFS 100        ; Standard contoured line, preset
X0:     DEFB 0          ; Screen position for
Y0:     DEFB 0          ; start of line
LEN:    DEFB 0          ; Length to plot
PBAR:   Ld HL,BAR
        LD A,(LEN)
        LD D,A          ; Counter
        LD BC,(X0)      ; BC = y0 * 256 + X0
PLOOP:  LD A,(HL)
        CP 0
        JR Z,BLACK
        SET 2,(IY+87) ; Inverse video (Spectrum system variable)
        JR DO
BLACK:  RES 2,(IY+87) ; Normal video (Spectrum system variable)
DO:     PUSH HL
        PUSH DE
        PUSH BC
        CALL PLOT
        POP BC
        POP DE
        POP HL
        INC B           ; Y = y + 1. No change in x
        LD A,175        ; If off top of screen
        CP B
        JR C,PEND       ; then no more to plot
        DEC D           ; Count point just plotted
        XOR A
        CP D            ; If LEN points done
        JR Z,PEND       ; then no more
        INC HL          ; Next point on bar
        JR PLOOP
PEND:   RET
        END


        ORG 61300       ; MAPS - harness, scans rectangular area to be mapped
X0:     DEFW 0          ; Start of plot, top left on map
Y0:     DEFW 0
XL:     DEFW 0          ; Start of current line on map
YL:     DEFW 0
XH:     EQU 63441       ; Current position on map (global coordinates)
YH:     EQU 63444
DXL:    DEFW 0          ; Map increments along scan line, as diagram above
DYL:    DEFW 0
DXC:    DEFW 0          ; MAP increments between scans (ie, column)
DYC:    DEFW 0
NX:     DEFB 0          ; No of points in scan line, 0..255 or 0..31
NY:     DEFB 0          ; No of lines, 0..191 or 0..23
XS:     DEFB 0          ; Current screen x, 0..255
YS:     DEFB 0          ; Current screen y, 191..0
XX:     DEFB 0          ; Current screen character x, 0..31
```

```
YX:     DEFB 0          ; Current screen character y, 0..23
MADDR:  DEFW 0          ; Address of 1-point kernel for current map type -
                        ; poke from BASIC first
FHEAD:  LD HL,(X0)      ; Start first line
        LD (XL),HL
        LD HL,(Y0)
        LD (YL),HL
        XOR A
        LD (XH-1),A     ; No fractional positions
        LD (YH-1),A
        LD A,(NY)       ; No of lines
        LD B,A          ; B = line counter
        LD A,191        ; Line start on screen (175 for FINEC)
        LD (YS),A
        XOR A
        LD (YX),A
FLINE:  PUSH BC         ; Start any line
        LD HL,(XL)      ; Work point at line start
        LD (XH),HL
        LD HL,(YL)
        LD (YH),HL
        LD A,(NX)       ; No of points in line
        LD B,A          ; B = point counter
        XOR A
        LD (XS),A       ; Line start on screen
        LD (XX),A
FPT:    PUSH BC         ; Do one point
        LD HL,(MADDR)   ; Get address of kernel for current map type
        JP (HL)         ; and go there
FRET:   POP BC          ; returning always to here
        DJNZ NEXTP
        POP BC
        DJNZ NEXTL
        RET
; Next point in a line:
NEXTP:  LD HL,(XH)
        LD DE,(DXL)
        ADD HL,DE
        LD (XH),HL
        LD HL,(YH)
        LD DE,(DYL)
        ADD HL,DE
        LD (YH),HL
        LD HL,XX        ; Increment character no
        INC (HL)        ;           (to handle all map types)
        LD HL,XS        ; Increment pixel no
        INC (HL)
        JR FPT          ; Do next point
; Next line:
NEXTL:  LD HL,(XL)
        LD DE,(DXC)
        ADD HL,DE
        LD (XL),HL
```

```
        LD HL,(YL)
        LD DE,(DYC)
        ADD HL,DE
        LD (YL),HL
        LD HL,YX
        INC (HL)      ; Character lines count up from 0 at top
        LD HL,YS
        DEC (HL)      ; Pixel lines count down from 191 at top
        JR FLINE      ; Do next line
        END
```

Now for some kernels…

```
        ORG 61240  ; VIEW3D - a map kernel - (MADDR) = VIEW
HEIGH:  EQU 62737
LH:     EQU 63011
X0:     EQU 61600
Y0:     EQU 61601
LEN:    EQU 61602
PBAR:   EQU 61603
XS:     EQU 61318
YS:     EQU 61319
FRET:   EQU 61385
VIEW:   CALL HEIGH ; (LH) = int (height (XH, YH))
        LD HL,(LH)
        LD BC,204  ; Lake height
        AND A      ; Clear carry
        SBC HL,BC  ; HL = HL - lake height
        SRA H
        RR L
        SRA H
        RR L
        SRA H
        RR L       ; HL = HL / 8
        LD A,L
        CP 128     ; If < 0
        JR C,HPOS
        XOR A      ; then A = 0
HPOS:   INC A
        LD (LEN),A
        LD A,(YS)  ; 191..0
        SUB 70
        LD (Y0),A  ; (i0 in BASIC version)
        LD A,(XS)
        LD (X0),A
        CALL PBAR
        JP FRET    ; End of kernel
        END
```

The next one, FINEC, is very similar:

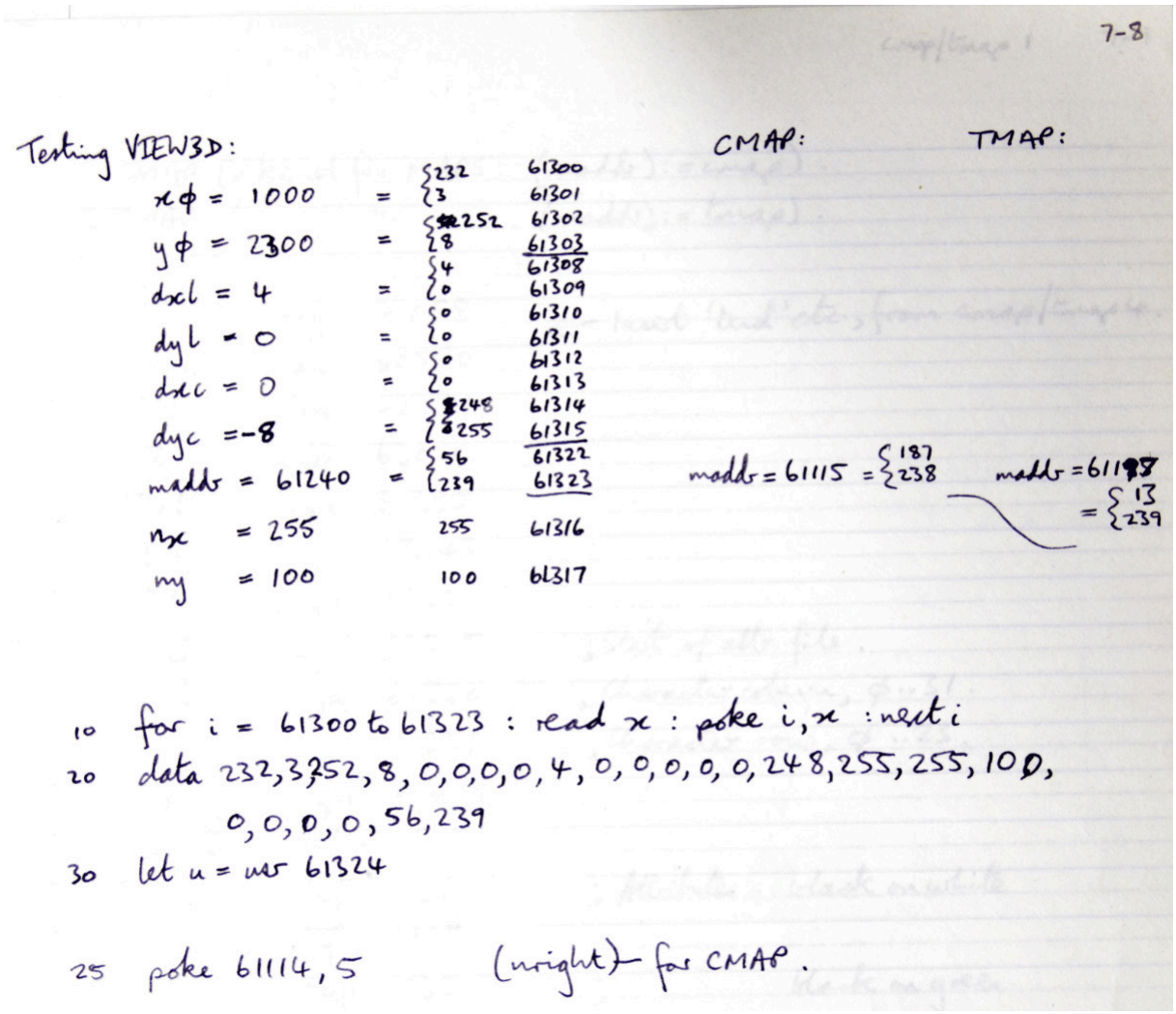
```
        ORG 61240  ; FINEC - fine contours kernel - (MADDR) = FINEC
HEIGH:  EQU 62737
PLOT:   EQU 22E5H  ; (In ROM)
BAR:    EQU 61500
LH:     EQU 63011
X0:     EQU 61600
Y0:     EQU 61601
LEN:    EQU 61602
PBAR:   EQU 61603
XS:     EQU 61318
YS:     EQU 61319
FRET:   EQU 61385
VIEW:   CALL HEIGH ; (LH) = int (height (XH, YH))
        LD HL,(LH)
        LD BC,204  ; Lake height
        AND A      ; Clear carry
        SBC HL,BC  ; HL = HL - lake height
        SRA H
        RR L
        SRA H
        RR L
        SRA H
        RR L       ; HL = HL / 8
        LD A,L
        CP 128     ; If < 0
        JR C,HPOS
        XOR A      ; then A = 0
HPOS:   INC A
        LD H,0
        LD L,A     ; 191..0
        LD BC,BAR
        ADD HL,BC  ; HL indexes BAR array
        LD A,(HL)  ; Value to plot, from BAR
        CP 0
        JP Z,FRET  ; IF white, no plot
        LD BC,(XS) ; (XS) in C, (YS) in B
        CALL PLOT
        JP FRET    ; End of kernel
        END
```

To make fine contours map from BASIC:

```
8500 LET NX=255:LET NY=175:POKE 61322,72:POKE 61323,238:
        POKE 61348,175:GOTO 9500
```

and

```
6000 CLS:INPUT “Fine or coarse map? [f/c]”;F$:IF F$=”f” THEN GOTO 8500
6100 LET NX=32:LET NY=24:POKE 61322,187:POKE 61323,238:GOTO 9500
```

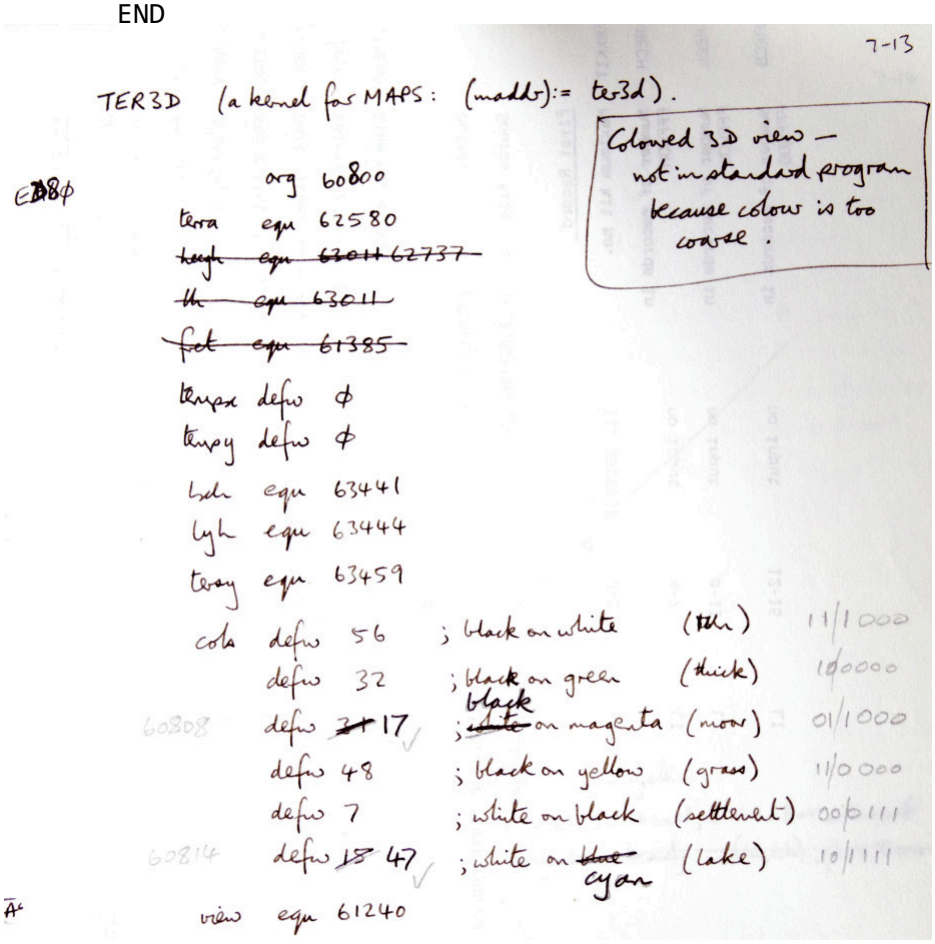


The next chunk of code includes 2 kernels. CMAP is the coarse contour map and TMAP is the terrain map.

```
        ORG 61088       ; CMAP & TMAP kernels
HEIGH:  EQU 62737
LH:     EQU 63011
FRET:   EQU 61385
TERRA:  EQU 62580
TATTR:  EQU 63745
T0:     EQU 63757
SAF:    EQU 22528       ; Start of attr file
XX:     EQU 61320       ; Character column, 0..31
YX:     EQU 61321       ; Character row, 0..23
LXH:    EQU 63442       ; Global position on map
LYH:    EQU 63445
TERSY:  EQU 63459
SYMS:   DEFM "r"
        DEFB 56         ; Black on white
        DEFM "t"
        DEFB 32         ; Black on green
```

```
        DEFM "m"
        DEFB 31         ; White on magenta
        DEFM "g"
        DEFB 48         ; Black on yellow
        DEFM "s"
        DEFB 7          ; White on black
        DEFM "l"
        DEFB 15         ; White on blue
NRIGH:  DEFB 5          ; No of right shifts to scale height (must not be 0)
CHAR:   DEFB 0
        DEFB 0          ; End of CHAR string, for T0
CMAP:   CALL HEIGH
        LD DE,(LH)
        LD A,D
        CP 0
        JR NZ,SHIFT
        LD A,E
        CP 204          ; Lake height
        JR NC,SHIFT
        LD E,200        ; If lake replace with surface (as in TERRA)
SHIFT:  LD A,(NRIGH)
        LD B,A
CLOOP:  SRL D
        RR E            ; E = height to plot
        DJNZ CLOOP
        LD A,'<'        ; Lowest height band "letter"
        ADD A,E
        AND 7FH         ; No characters above 128!
        LD (CHAR),A     ; To display using T0
        AND 7           ; Paper colour
        ADD A,A
        ADD A,A
        ADD A,A         ; Moves paper colour to bits 3, 4, 5
        CP 40           ; 101000 - check contrast for letter
        JR NC,SHOW      ; Ink black
        OR 7            ; Ink white
SHOW:   LD (TATTR),A
        LD A,(YX)
        LD L,A
        LD H,0
        ADD HL,HL
        ADD HL,HL
        ADD HL,HL
        ADD HL,HL
        ADD HL,HL       ; 5 times: HL = HL * 32
        LD A,(XX)
        LD C,A
        LD B,0
        ADD HL,BC
        LD BC,SAF
        ADD HL,BC       ; HL points to attr file position for T0
        LD DE,CHAR      ; Point to string to display
        CALL T0
```

```
        JP FRET         ; End of CMAP kernel
TMAP:   LD HL,(LXH)     ; Terrain map kernel
        LD (TEMPX),HL   ; Save coordinates because FEATU alters them
        LD HL,(LYH)
        LD (TEMPY),HL
        CALL TERRA
        LD HL,(TEMPX)
        LD (LXH),HL
        LD HL,(TEMPY)
        LD (LYH),HL
        LD A,(TERSY)
        LD C,A
        LD B,0
        LD HL,SYMS
        ADD HL,BC
        JP TEND
; Rest of TMAP code went to start of module because out of space to next
; module
        ORG 61088
TEND:   LD A,(HL)       ; Character to display
        LD (CHAR),A
        INC HL
        LD A,(HL)       ; Attributes
        JR SHOW
TEMPX:  DEFW 0
TEMPY:  DEFW 0
        END
```



```
EB9Ø   ter3D:   ld  hl,(lxh)
                ld  (tempx),hl
                ld  hl,(lyh)
                ld  (tempy),hl
                call terra
                ld  hl,(tempx)
                ld  (lxh),hl
                ld  hl,(tempy)
                ld  (lyh),hl
                ld  a,(tery)
                ld  c,a
                ld  b,Ø
60849           ld  hl, cols
60852           add hl,bc      9
                ~~add hl,bc~~
60853           ld  a,(hl)     126
EDB6=60854      ld  (23695),a      ; ATTR_T, in system.
                jp  view           ; To VIEW3D kernel, to draw bar, ~~except height is already in (lh,hh), from terra.~~
```

33 13~~5~~2 237
21 85 ED

~~EA9C~~
BC

~~50 + 256×143 =~~

60854 50
5 143
6 92 — 23695 ≡ ATTR_T
7 195
8 59
9 239 → 61243 ✗

141
92 — 23693 ≡ ATTR_P ✗

56
239 → 61240 ✓

b: 10.37.45
10.35.35
2.10

A: 10.43.43
10.38.10
5.33

Part 8 – The complex forest

The forest can be changed by altering the tables of coefficients which are used in terrain generation (see Part 4). This does not alter the angular nature of the terrain however, with its plane surfaces. The switch to the so-called complex forest involves changing the machine code ~~from~~ between addresses 62783 and 62802 inclusive, and the use of a table of 256 values stored between 60500 and 60755. The table forms a profile, shown on the next page, which replaces the simple saw-tooth function used in generating the normal forest (see p. 4-2). This means that the height/attributes generating routine no longer computes

$$h_i = 128 - \text{abs}\left((a_i x + b_i y) \bmod 256 - 128\right)$$

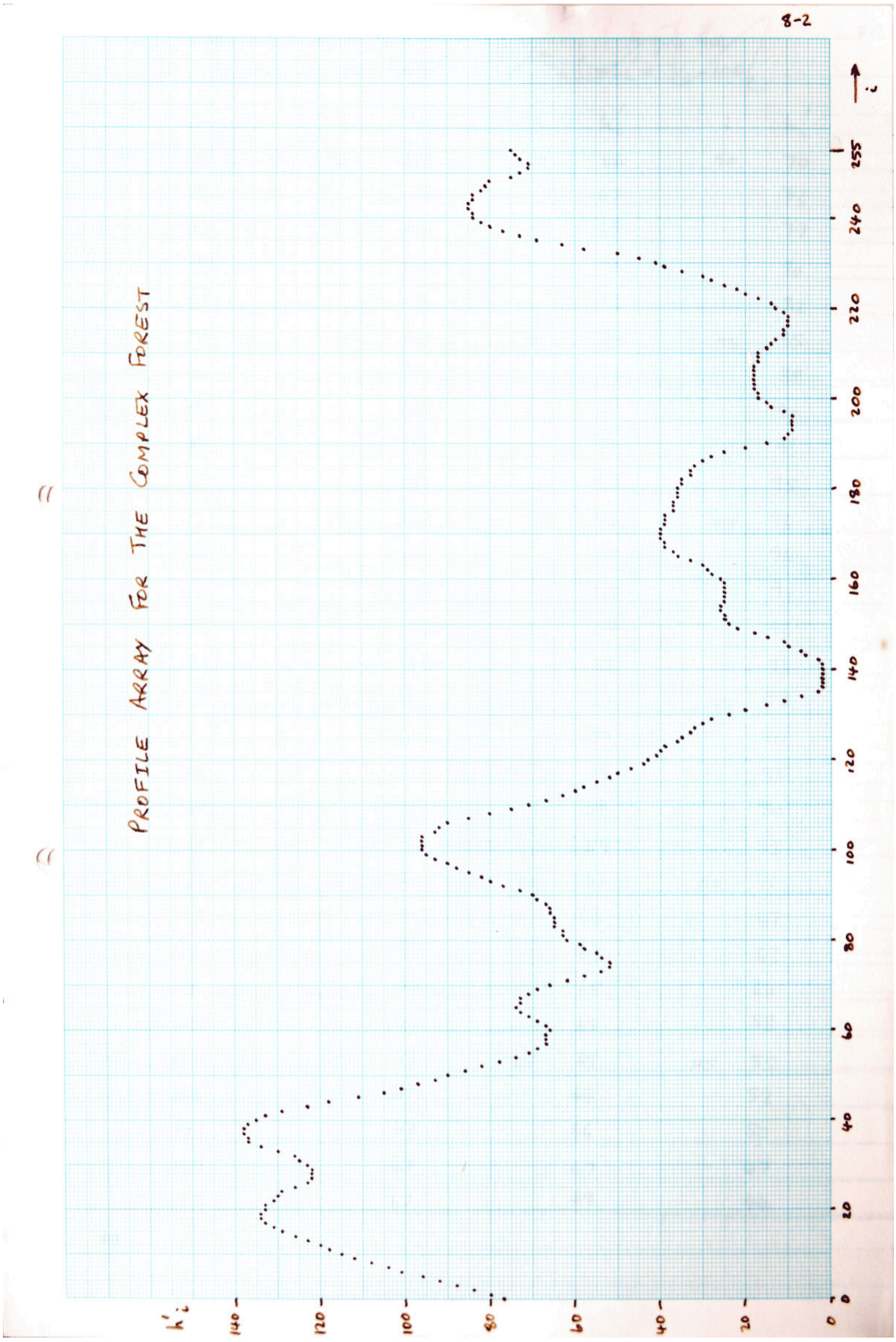
but instead looks up

$$h'_i((a_i x + b_i y) \bmod 256)$$

in the profile table (array), to form $H' = \sum_{i=1}^{5} h'_i$.

The assembly program between labels norm1 and ~~norm2~~ prof+2 (inclusive) on page 4-8 is therefore replaced by the following when the user invokes the complex forest. This code and the original are swapped by poke statements from the Basic shell – see page 9-9.

```
comp1   ld    h,0       ; L := result mod 256.
        ld    bc,fstbt  ; Point to start of profile array, at 60500.
        add   hl,bc
        ld    c,(hl)    ; BC := h'i .
        ld    b,0
        ld    hl,(th)
        add   hl,bc     ; Add into sum for H'.
        ld    (th),hl
        pop   bc        ; Retrieve loop counter, i (as normal).
        djnz  hloo1     ; Next i
```

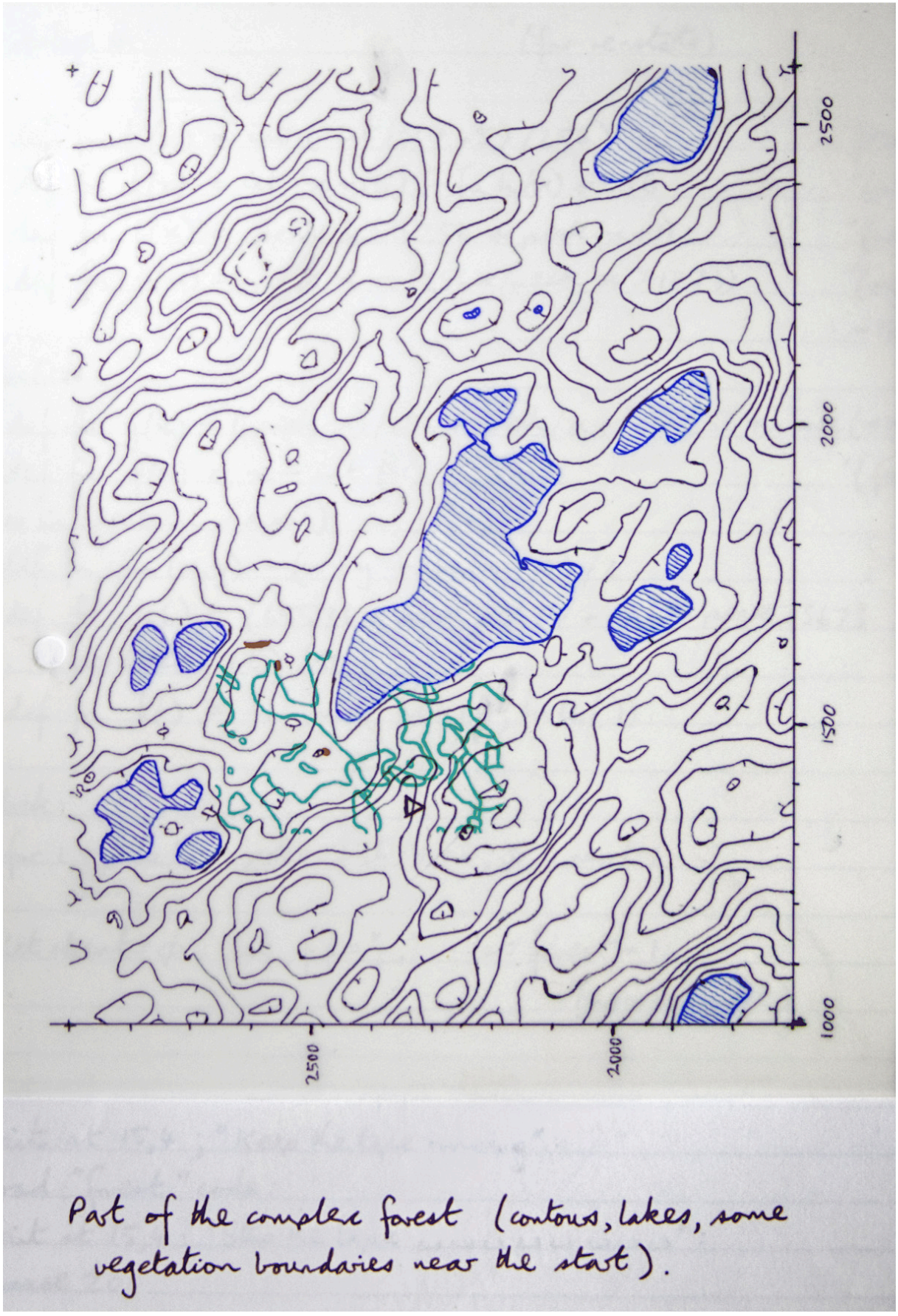

8-2
PROFILE ARRAY FOR THE COMPLEX FOREST
h'i
i
0
20
40
60
80
100
120
140
160
180
200
220
240
255

NB: These numbers should be scaled by ....? to get the mapped Complex Forest. ← hi' := hi' * 1.36 - 100;

i	h'i	i	hi'	i	hi'	i	hi'
0	77	30	123	60	66	90	70
	80		125		67		73
	84		126		69		77
	88		130		71		80
	92		134		73		82
5	96	35	137	65	74	95	85
	101		137		73		88
	104		138		73		90
	108		138		71		93
	112		137		69		95
10	115	40	135	70	66	100	96
	118		133		62		96
	120		129		58		96
	123		123		54		96
	126		118		52		93
15	129	45	111	75	52	105	92
	131		105		54		90
	133		101		55		85
	134		97		58		80
	134		93		59		75
20	133	50	90	80	62	110	71
	133		86		63		67
	131		82		63		63
	130		78		65		60
	129		74		65		58
25	126	55	71	85	65	115	55
	123		69		66		52
	122		67		66		50
	122		67		67		47
	122		67		69		44

i	h'_i	i	h'_i	i	h'_i	i	h'_i
120	43	150	24	180	36	210	17
	41		25		35		15
	40		25		35		14
	39		26		33		13
	36		26		33		11
125	35	155	25	185	32	215	11
	33		25		30		10
	32		25		28		10
	30		25		25		10
	28		25		20		11
130	24	160	26	190	15	220	13
	20		28		11		14
	15		29		10		17
	11		30		9		20
	7		33		9		22
135	3	165	36	195	9	225	25
	2		37		9		28
	2		39		11		30
	2		39		14		35
	2		40		15		39
140	2	170	40	200	17	230	41
	2		40		17		45
	3		39		18		50
	6		39		18		58
	7		39		18		63
145	10	175	37	205	18	235	69
	11		37		18		73
	15		37		18		77
	18		36		17		80
	22		36		17		82

i	h'_i
240	84
	84
	85
	85
	84
245	84
	82
	81
	80
	75
250	73
	71
	71
	73
	74
255	75



Part of the complex forest (contours, lakes, some vegetation boundaries near the start).

Part 9 - The BASIC shell

I have annotated the following listing with comments in the form REM ***.

```
0 REM The Forest by Graham T. Relf {C}1983 Phipps Associates
2 CLEAR 60000
3 PRINT AT 3,11;"THE FOREST";AT 5,2;"A simulation of
orienteering";AT 7,7;"By Graham T. Relf";AT 10,4;"{C} 1983
Phipps Associates"
4 PRINT AT 15,6;"KEEP THE TAPE RUNNING": INK 7: LOAD
"forest"CODE : INK 0: PRINT AT 15,6; FLASH 1;"    STOP THE
TAPE    ": FOR x=1 TO 12: BEEP .05,10: BEEP .05,15: NEXT x:
PAUSE 200
5 RESTORE 5: REM for re-starts
20 DEF FN h(x)=INT (INT (x+.5)/256): REM *** MSB of x
25 DEF FN l(x)=INT (x+.5)-FN h(x)*256: REM *** LSB of x
30 DEF FN i(x)=PEEK x+256*PEEK (x+1): REM *** word value
40 DEF FN j(x)=(PEEK x)/256+PEEK (x+1)+256*PEEK (x+2): REM ***
3-byte value
50 DEF FN m(x,y)=(x+y+ABS (x-y))/2
60 DEF FN u()=(65536*PEEK 23674+256*PEEK 23673+PEEK 23672)/50
70 DEF FN t()=FN m(FN u(),FN u()): REM *** time, as in
Sinclair manual p129
80 FOR i=0 TO 2: POKE 23674-i,0: NEXT i: REM *** set clock
90 LET cheat=0: LET forest=1: LET f$=" ": REM *** normal
forest map
99 REM *** Adresses in machine code:
100 LET xattr0=63850: LET ucls=63852
110 LET uinit=63298: LET uhigh=62040
120 LET uturn=62052: LET udispl=62055
130 LET umove=61850: LET uback=61740
140 LET uright=61700: LET uleft=61720
150 LET xcode=63464: LET xfinfl=63456
160 LET xfh=63010: LET xlh=63011: LET xhh=63012
170 LET xbear=63431: LET xtg=63458
180 LET xlxh=63441: LET xhxh=63442
185 LET xhxt=63436: LET xhyt=63439
190 LET xlyh=63444: LET xhyh=63445
200 LET uterra=62580: LET xobsfe=63463
210 LET xfhh=63446: LET xlhh=63447: LET xhhh=63448
215 LET xfhg=63449: LET xlhg=63450: LET xhhg=63451
220 LET upbar=61603: LET xx0=61600: LET xy0=61601: LET
xlen=61602
299 REM *** Conversion factors, b-degrees to normal degrees
and back:
300 LET d2b=256.0/360.0: LET b2d=360.0/256.0
309 REM *** Course data:
310 LET nc=20: DIM a$(nc,2): LET mc=12: DIM c$(mc,2): DIM
```

```
d$(mc,12): FOR i=1 TO mc: READ c$(i),d$(i): NEXT i
320 DATA "BN","DEPRESSION","BO","ROCK
OUTCROP","BP","DEPRESSION"
321 DATA "BM","POND","BL","KNOLL","BN","MINE SHAFT"
322 DATA "BP","KNOLL","BO","MINE SHAFT","AO","MINE SHAFT"
323 DATA "BD","NICHE","BN","ROCK OUTCROP","BA","NICHE"
399 REM *** Terrain factors (1, 3, 5, 7, 9, 11):
400 DIM e(11): FOR i=1 TO 11 STEP 2: READ e(i): NEXT i: DATA
2.0,6.0,5.0,2.0,2.5,9.0
499 REM *** Show title page:
500 BORDER 1: LET i=USR uinit
550 IF INKEY$="" THEN GO TO 550
555 GO TO 1000
899 REM *** T command:
900 LET time=FN t(): LET hour=INT (time/3600): LET time=time-
hour*3600: LET mins=INT (time/60): LET secs=INT (time-
mins*60): PRINT AT 0,0;"ELAPSED TIME: ";hour;" ";mins;"
";secs;" ": RETURN
999 REM *** Key actions when stationary:
1000 LET i=USR umove: LET ht=FN j(xfhg)
1002 LET lastht=ht
1010 IF PEEK xcode<>32 THEN PRINT AT 21,14; PAPER 7; INK 2;
OVER 1;CHR$ PEEK xcode;CHR$ PEEK (xcode+1);
1012 IF PEEK xtg=10 THEN PRINT AT 0,0;"In the lake!";
1015 LET i$=INKEY$: IF i$="" THEN GO TO 1015
1020 IF i$="5" THEN LET u=USR uleft: GO TO 1010
1030 IF i$="8" THEN LET u=USR uright: GO TO 1010
1040 IF i$="6" THEN LET u=USR uback: GO TO 1010
1050 IF i$="7" THEN GO TO 1500
1060 IF i$="B" THEN GO TO 2000
1070 IF i$="D" THEN GO TO 2100
1080 IF i$="C" THEN GO TO 2200
1090 IF i$="P" THEN GO TO 2300
1100 IF i$="T" THEN GO SUB 900: GO TO 1010
1110 IF i$="M" THEN GO TO 3000
1200 GO TO 1015
1499 REM *** Key actions when moving:
1500 LET delay=(3+(ht-lastht))*e(PEEK (xtg)+1): IF delay>0
THEN PAUSE delay
1502 LET u=USR umove: LET lastht=ht: LET ht=FN j(xfhg)
1505 IF PEEK xfinfl=1 THEN GO TO 2900
1510 IF PEEK xtg=10 THEN GO TO 1010
1520 LET i$=INKEY$: IF i$="" THEN GO TO 1500
1530 IF i$=CHR$ 8 OR i$="5" THEN LET u=USR uleft: GO TO 1500
1540 IF i$=CHR$ 9 OR i$="8" THEN LET u=USR uright: GO TO 1500
1550 IF i$=CHR$ 10 OR i$="6" THEN LET u=USR uback: GO TO 1010
1560 IF i$=CHR$ 11 OR i$="7" THEN GO TO 1500
1570 GO TO 1010
```

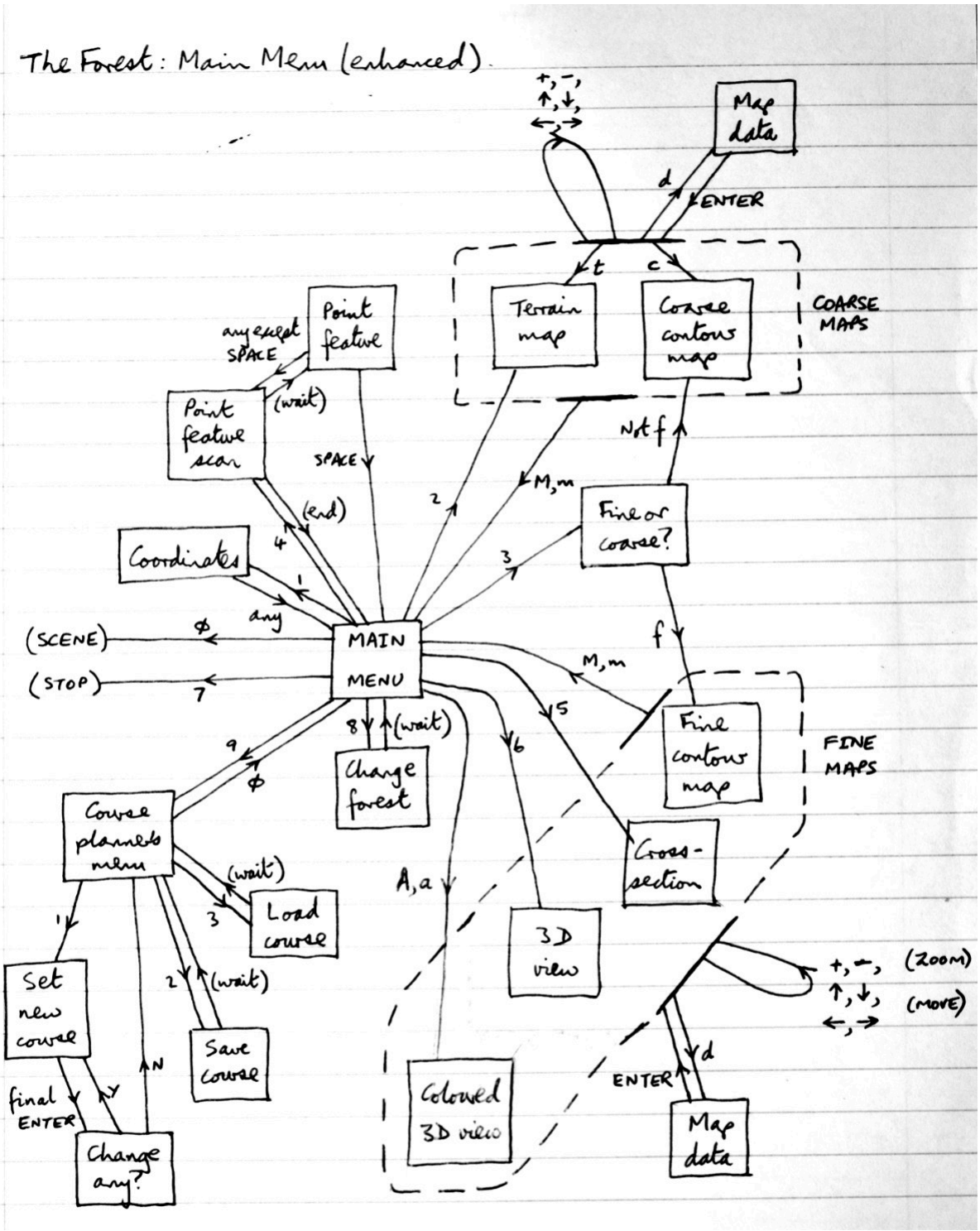
```
1999 REM *** B command:
2000 LET bear=INT (b2d*PEEK xbear): PRINT AT 0,0;"BEARING:
";bear;" degrees  ";
2010 INPUT "New bearing:"; LINE b$: IF LEN b$<1 THEN GO TO
1000
2015 IF b$(1)<"0" OR b$(1)>"9" THEN GO TO 1000
2020 LET b=VAL b$: IF b<0 OR b>360 THEN GO TO 1000
2030 IF b=360 THEN LET b=0
2040 POKE xbear,b*d2b: GO TO 1000
2099 REM *** D command:
2100 CLS : PRINT "Course A    5.5km.": PRINT : FOR i=1 TO mc:
PRINT i;TAB 4;c$(i);"  ";d$(i): NEXT i: PRINT : PRINT
"Navigate to finish (no tapes)"
2110 LET i$=INKEY$: IF i$="" THEN GO TO 2110
2120 GO TO 1000
2199 REM *** C command:
2200 CLS : PRINT "Control card": PRINT : FOR i=1 TO nc: PRINT
i;TAB 4;a$(i): NEXT i
2210 GO TO 2110
2299 REM *** P command:
2300 IF PEEK xcode=32 THEN GO TO 1010
2310 LET m$="PUNCH: control number? ": GO SUB 5200: LET cno=x:
IF cno>0 AND cno<=nc THEN LET a$(cno)=CHR$ (PEEK xcode)+CHR$
(PEEK (xcode+1))
2320 GO TO 2120
2899 REM *** Give up or reach finish:
2900 CLS : BORDER 7: GO SUB 900: PRINT AT 0,24; BRIGHT 1;
PAPER 0; INK 7;"FINISH": PRINT
2910 FOR i=1 TO mc: IF a$(i)="  " THEN PRINT "Missing number
";i: GO TO 2930
2920 IF a$(i)<>c$(i) THEN PRINT "Wrong number ";i
2930 NEXT i
2940 IF cheat=0 THEN STOP
2950 PRINT "YOU CHEATED ";: IF cheat=1 THEN PRINT "ONCE!":
STOP
2960 PRINT cheat;" TIMES!"
2999 STOP
3000 BORDER 7: CLS : PRINT " THE FOREST : MAIN MENU": PRINT :
REM *** M command
3010 PRINT " 0) Return to scene (no penalty)"
3020 PRINT " 1) Get coordinates"
3030 PRINT " 2) Map terrain types"
3040 PRINT " 3) Map contours"
3050 PRINT " 4) Scan for point features"
3060 PRINT " 5) Draw cross-section"
3070 PRINT " 6) Draw 3D view"
3080 PRINT " 7) Give up (stop)"
3081 IF forest=1 THEN PRINT " 8) Go to more complex forest"
```

```
3082 IF forest=2 THEN PRINT " 8) Back to normal forest"
3084 PRINT " 9) Alter the set course"
3085 PRINT : PRINT " Which?"
3090 PRINT : PRINT : PRINT " NB: 1 to 6 are not possible in":
PRINT " real orienteering, so they are": PRINT " counted as
cheating and will be": PRINT " reported at the finish."
3095 PRINT " After an option any key returns": PRINT " to this
menu."
3100 LET i$=INKEY$: IF i$="" THEN GO TO 3100
3105 IF i$>"0" AND i$<"7" THEN LET cheat=cheat+1
3110 IF i$="0" THEN BORDER 1: GO TO 1000
3120 IF i$="1" THEN GO SUB 4000
3130 IF i$="2" THEN GO SUB 5000
3140 IF i$="3" THEN GO SUB 6000
3150 IF i$="4" THEN GO SUB 7000
3160 IF i$="5" THEN GO SUB 8000
3170 IF i$="6" THEN GO SUB 9000
3180 IF i$="7" THEN GO TO 2900
3185 IF i$="8" THEN GO SUB 3500
3190 IF i$="9" THEN GO SUB 7500
3195 GO TO 3000
3499 REM *** 8) ... switch forest
3500 IF forest=2 THEN GO TO 3700
3510 LET forest=2: RESTORE 3510
3520 FOR i=62783 TO 62802: READ x: POKE i,x: NEXT i
3530 DATA
38,0,1,84,236,9,78,6,0,42,35,246,9,34,35,246,193,16,207,201
3540 FOR i=63013 TO 63022: READ x: POKE i,x: NEXT i
3560 DATA 0,27,13,26,21,21,22,11,29,1
3590 RETURN
3700 LET forest=1: RESTORE 3700
3710 FOR i=62783 TO 62802: READ x: POKE i,x: NEXT i
3720 DATA
85,95,122,254,127,56,10,123,47,198,1,95,122,47,206,0,87,42,34,
246
3730 FOR i=63013 TO 63022: READ x: POKE i,x: NEXT i
3750 DATA 200,3,165,37,127,96,101,202,13,157
3790 RETURN
3999 REM *** 1) Get coordinates
4000 CLS : PRINT : PRINT " You are standing at"
4010 PRINT " x = ";FN i(xhxt-1): PRINT " y = ";FN i(xhyt-1)
4020 IF LEN INKEY$ THEN GO TO 4020
4030 IF INKEY$="" THEN GO TO 4030
4040 RETURN
4999 REM *** 2) Map terrain types
5000 LET nx=32: LET ny=24: POKE 61322,13: POKE 61323,239: GO
TO 9500
5200 INPUT (m$); LINE q$: IF NOT LEN q$ THEN GO TO 5200
```

```
5210 FOR x=1 TO LEN q$: IF q$(x)<"0" OR q$(x)>"9" THEN BEEP
.4,-10: GO TO 5200
5220 NEXT x: LET x=VAL q$
5230 RETURN
5999 REM *** 3) Map contours
6000 CLS : INPUT "Fine or coarse map? "; LINE f$: IF CHR$ CODE
f$="f" OR CHR$ CODE f$="F" THEN GO TO 8500
6010 LET nx=32: LET ny=24: POKE 61322,187: POKE 61323,238: GO
TO 9500
6999 REM *** 4) Scan for point features
7000 LET nx=1: LET ny=1: GO TO 9500
7100 LET m$="Step size? [1..8m] ": GO SUB 5200: LET ss=x: IF
ss<1 OR ss>8 THEN GO TO 7100
7110 LET s2=INT (ss/2): LET x0=ss*INT (x0/ss)-s2: LET
y0=ss*INT (y0/ss)-s2
7120 LET nx=w/ss+1: LET ny=h/ss+1
7130 LET xl=FN l(x0): LET xh=FN h(x0): POKE xhxt-2,0: POKE
xhxt-1,xl: POKE xhxt,xh
7140 LET yl=FN l(y0): LET yh=FN h(y0): POKE xhyt-2,0: POKE
xhyt-1,yl: POKE xhyt,yh
7150 LET b=128: LET dy=ss: FOR i=1 TO nx
7160 IF b=0 THEN GO TO 7180
7170 LET b=0: GO TO 7190
7180 LET b=128
7190 POKE xbear,b: FOR j=1 TO ny
7200 LET u=USR umove: POKE xbear,b: PRINT AT 0,0;"x = ";FN
i(xhxt-1);" y = ";FN i(xhyt-1);
7205 IF PEEK xcode<>32 THEN PRINT AT 21,14; PAPER 7; INK 2;
OVER 1;CHR$ PEEK xcode;CHR$ PEEK (xcode+1)
7210 IF PEEK xobsfe<>0 THEN PRINT AT 0,23;"Any key";: GO SUB
7900
7220 LET yl=yl+dy: IF yl>=256 THEN LET yl=yl-256: LET yh=yh+1
7230 IF yl<=-1 THEN LET yl=yl+256: LET yh=yh-1
7240 IF INKEY$=" " THEN GO TO 3000
7250 POKE xhyt-1,yl: POKE xhyt,yh: NEXT j
7260 LET u=USR uback: LET xl=xl+ss: IF xl>=256 THEN LET xl=xl-
256: LET xh=xh+1
7270 IF xl<=-1 THEN LET xl=xl+256: LET xh=xh-1
7280 POKE xhxt-1,xl: POKE xhxt,xh: LET dy=-dy: NEXT i
7290 GO TO 3000
7499 REM *** 9) Alter the set course
7500 BORDER 7: CLS : PRINT " COURSE PLANNER'S MENU": PRINT
7510 PRINT " 0) Return to main menu"
7520 PRINT " 1) Set new course"
7530 PRINT " 2) Save course on tape"
7540 PRINT " 3) Load course from tape"
7550 PRINT : PRINT " Which?"
7560 LET i$=INKEY$: IF i$="" THEN GO TO 7560
```

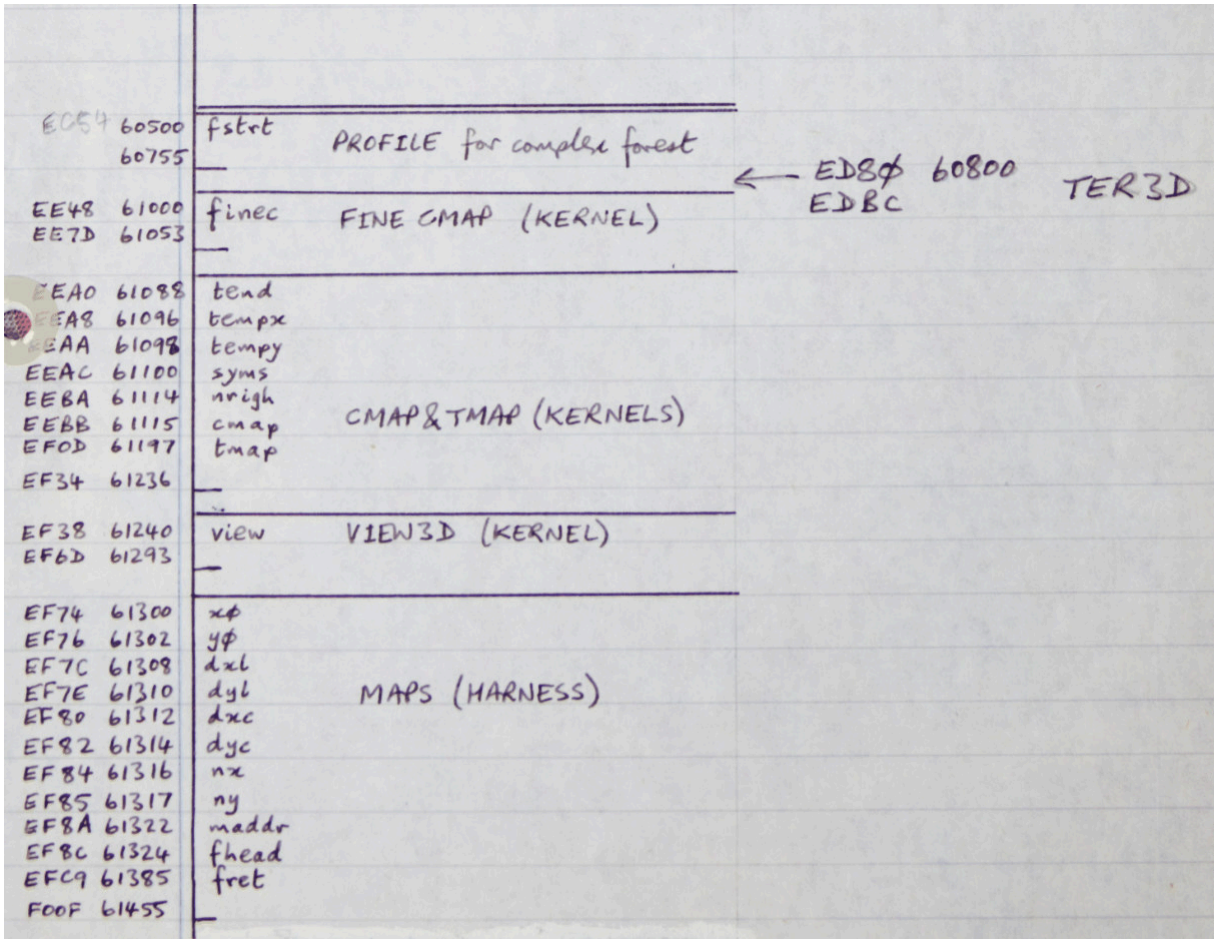
```
7570 IF i$="0" THEN GO TO 3000
7580 IF i$="1" THEN GO SUB 7800
7590 IF i$="2" THEN GO SUB 7700
7600 IF i$="3" THEN GO SUB 7750
7610 GO TO 7500
7700 CLS : PRINT "Saving course on tape (3 files)"
7710 DIM l(2): LET l(1)=nc: LET l(2)=mc
7720 SAVE "lengths" DATA l()
7730 SAVE "codes" DATA c$()
7740 SAVE "descs" DATA d$()
7745 RETURN
7750 CLS : PRINT "Load course from tape (3 files)"
7760 LOAD "lengths" DATA l()
7770 LOAD "codes" DATA c$()
7780 LOAD "descs" DATA d$()
7790 LET nc=l(1): LET mc=l(2)
7795 RETURN
7800 CLS : PRINT "SETTING NEW COURSE"
7805 LET m$="How many controls? [1.."+STR$ nc+"]": GO SUB
5200: LET mc=x: IF mc<1 OR mc>nc THEN GO TO 7805
7810 DIM a$(nc,2): DIM c$(mc,2): DIM d$(mc,12)
7815 FOR i=1 TO mc: GO SUB 7880: NEXT i
7820 INPUT "Change any? [y/n] "; LINE h$: IF CHR$ CODE h$<>"y"
AND CHR$ CODE h$<>"Y" THEN GO TO 7500
7825 LET m$="Control no.? [1.."+STR$ (mc)+"]": GO SUB 5200:
LET i=x: IF i<1 OR i>mc THEN GO TO 7825
7830 GO SUB 7880: GO TO 7820
7880 INPUT "Control ";(i);": code? "; LINE c$(i)
7885 INPUT "Control ";(i);": description?"; LINE d$(i)
7890 PRINT AT i+2,2;i;TAB 5;c$(i);TAB 10;d$(i);: RETURN
7900 IF INKEY$="" THEN GO TO 7900
7910 RETURN
7999 REM *** 5) Draw cross-section
8000 LET nx=255: LET ny=1: LET h=0: POKE 61322,56: POKE
61323,239: GO TO 9500
8500 LET nx=255: LET ny=175: POKE 61322,72: POKE 61323,238:
POKE 61348,175: GO TO 9500
8999 REM *** 6) Draw 3D plot
9000 LET nx=255: LET ny=100: POKE 61322,56: POKE 61323,239: GO
TO 9500
9500 LET nnx=1: LET nny=1: BORDER 7: CLS : PLOT 100,100: DRAW
90,30: IF i$<>"5" THEN DRAW -15,45: DRAW -90,-30: DRAW 15,-45
9510 PLOT 200,80: DRAW -170,0: DRAW 0,95: PLOT 100,90: DRAW
0,80: PLOT 100,130: DRAW 30,-20,-1.2
9520 PRINT AT 12,23;"x";: PRINT AT 0,2;"y";: PRINT AT
7,13;"b";: PRINT AT 0,12;"N";
9530 PRINT AT 8,18;"w";: PRINT AT 9,7;"x0,y0";: IF i$<>"5"
THEN PRINT AT 2,23;"h";
```

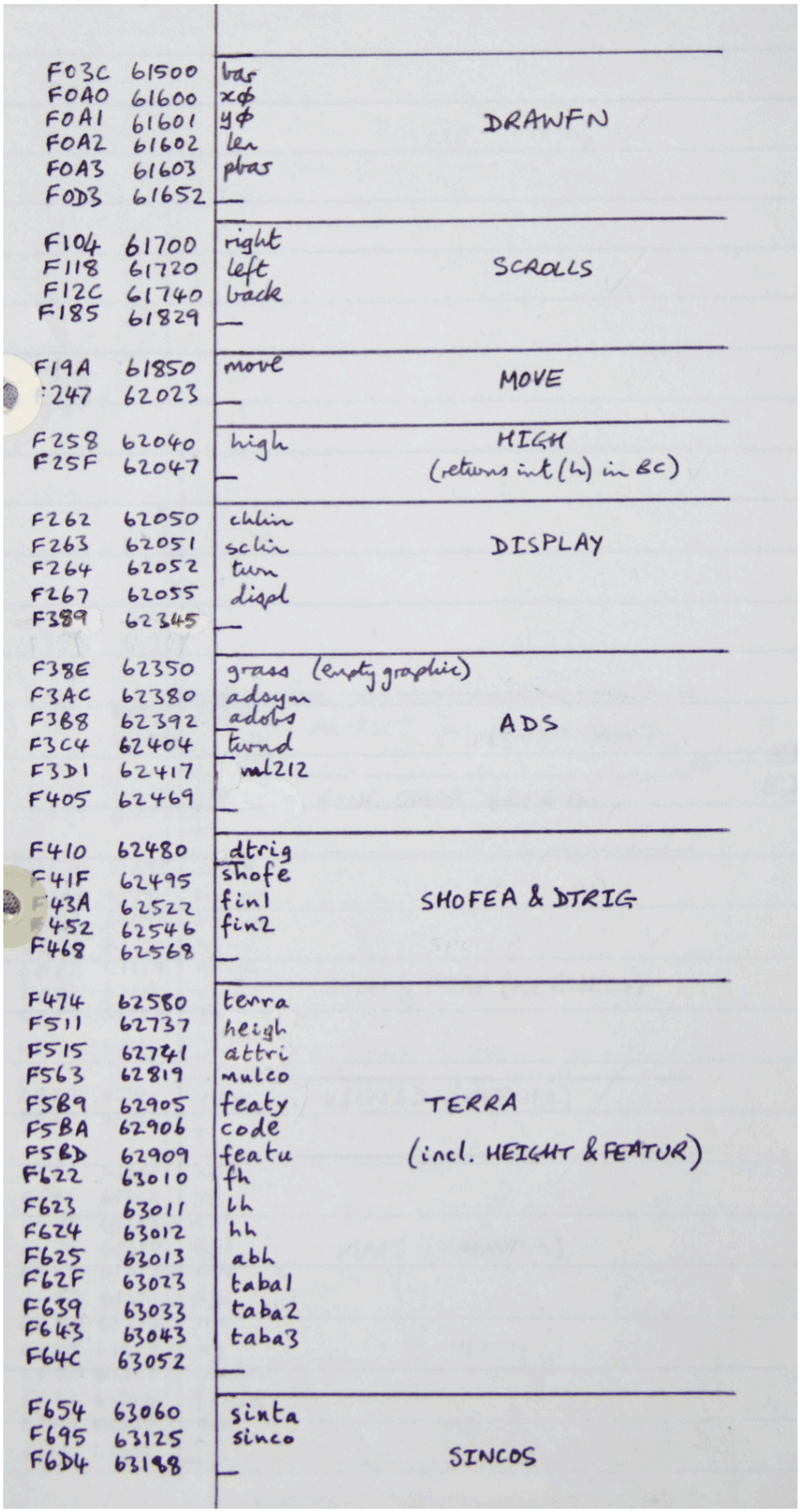
```
9600 LET j$="": LET m$="Corner of plot: x0 ?": GO SUB 5200:
LET x0=x: PRINT AT 15,0;"x0 = ";x0;
9610 LET m$="Corner of plot: y0 ?": GO SUB 5200: LET y0=x:
PRINT AT 16,0;"y0 = ";y0;: IF i$="4" THEN GO TO 9620
9615 INPUT "Specify w & h or scale? [W,S]"; LINE j$: IF CHR$
CODE j$="S" OR CHR$ CODE j$="s" THEN LET m$="Scale ? [n, as in
1:n,000]": GO SUB 5200: LET nnx=x: LET w=nnx*nx: LET h=nnx*ny:
LET nny=nnx: GO TO 9631
9620 LET m$="Width, w metres ?": GO SUB 5200: LET w=x: LET
nnx=w/nx
9630 IF i$<>"5" THEN LET m$="Height, h metres ?": GO SUB 5200:
LET h=x: LET nny=h/ny
9631 IF (j$="S" OR j$="s") AND (i$="5" OR i$="6" OR (i$="3"
AND f$="f")) THEN LET w=w/8: LET h=h*0.24
9632 PRINT AT 15,16;"w = ";w;" m.";: PRINT AT 16,16;"h = ";h;"
m.";: IF i$<>"4" THEN PRINT AT 17,0;"x scale = 1:";INT
(nnx*1000);: PRINT AT 18,0;"y scale = 1:";INT (nny*1000);
9635 IF i$="4" THEN GO TO 7100
9640 LET m$="Angle b degrees ?": GO SUB 5200: LET b=x: PRINT
AT 19,0;"b  = ";b;" degrees";
9642 IF (i$="3" AND f$<>"f") THEN LET m$="Contour interval?
[1.25..80m]": GO SUB 5200: LET ci=x: IF ci<1.25 OR ci>80 THEN
GO TO 9642
9643 IF (i$="3" AND f$<>"f") THEN POKE 61114,LN (6.4*ci)/LN 2
9645 LET br=b*PI/180: LET sb=SIN br: LET cb=COS br
9647 LET x0=x0-h*cb: LET y0=y0+h*sb: LET h=-h
9650 POKE 61301,FN h(x0): POKE 61300,FN l(x0)
9660 POKE 61303,FN h(y0): POKE 61302,FN l(y0)
9680 LET dxl=w*sb/nx: POKE 61309,FN h(dxl): POKE 61308,FN
l(dxl)
9690 LET dyl=w*cb/nx: POKE 61311,FN h(dyl): POKE 61310,FN
l(dyl)
9700 LET dxc=-h*cb/ny: POKE 61313,FN h(dxc): POKE 61312,FN
l(dxc)
9710 LET dyc=h*sb/ny: POKE 61315,FN h(dyc): POKE 61314,FN
l(dyc)
9720 POKE 61316,nx: POKE 61317,ny
9730 CLS : LET u=USR 61324
9740 POKE 61348,191
9900 IF INKEY$="" THEN GO TO 9900
9990 RETURN
9997 CLEAR : ERASE "m";1;"FOREST": ERASE "m";1;"forest": SAVE
*"m";1;"FOREST" LINE 9998: SAVE *"m";1;"forest"CODE
60500,5036: STOP
9998 CLEAR 60000: LOAD *"m";1;"forest"CODE : GO TO 5
9999 CLEAR : SAVE "FOREST" LINE 1: SAVE "forest"CODE
60500,5036: STOP
```

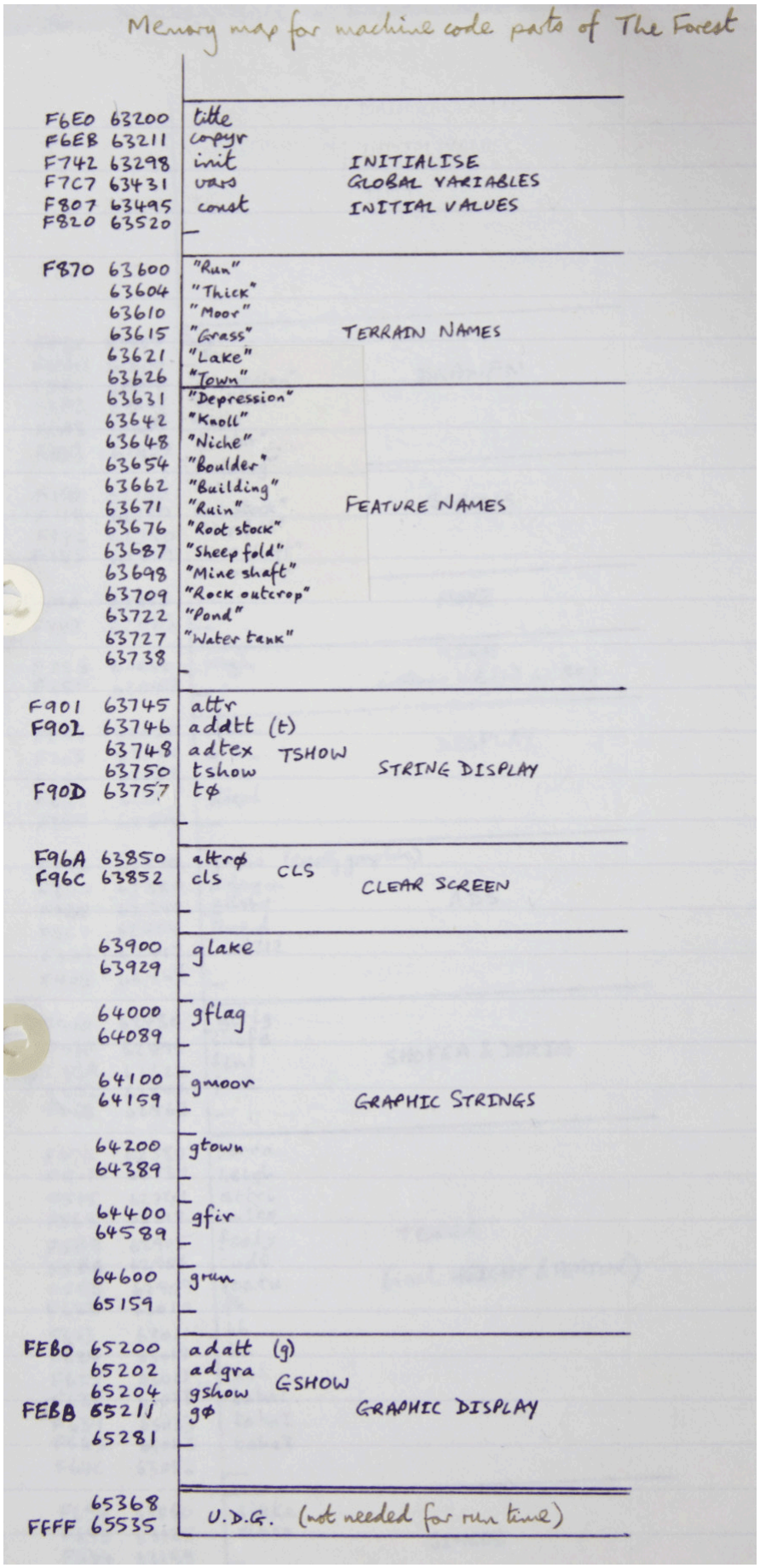

The Forest: Main Menu (enhanced)
+, -, ↑, ↓, ←, →
Map data
d
ENTER
t
c
Terrain map
Coarse contour map
COARSE MAPS
Point feature
any except SPACE
(wait)
Point feature scan
SPACE
(end)
Coordinates
4
1
any
2
M,m
Ntf
Fine or coarse?
3
f
(SCENE)
ϕ
MAIN MENU
(STOP)
7
M,m
5
Fine contour map
FINE MAPS
8
(wait)
Change forest
9
ϕ
6
Cross-section
Course planets menu
(wait)
3
Load course
A,a
3D view
1
Set new course
2
(wait)
Save course
N
final ENTER
Y
Change any?
Coloured 3D view
+, -, (ZOOM)
↑, ↓, (MOVE)
←, →
ENTER
d
Map data

Memory map for assembly parts of The Forest

See also page 24.




F03C 61500 bas
F0A0 61600 x$
F0A1 61601 y$
F0A2 61602 len
F0A3 61603 pbas
F0D3 61652
DRAWFN
F104 61700 right
F118 61720 left
F12C 61740 back
F185 61829
SCROLLS
F19A 61850 move
F247 62023
MOVE
F258 62040 high
F25F 62047
HIGH
(returns int(h) in BC)
F262 62050 chlin
F263 62051 schin
F264 62052 turn
F267 62055 displ
F389 62345
DISPLAY
F38E 62350 grass (empty graphic)
F3AC 62380 adsym
F3B8 62392 adobs
F3C4 62404 tvond
F3D1 62417 ml212
F405 62469
ADS
F410 62480 dtrig
F41F 62495 shofe
F43A 62522 fin1
F452 62546 fin2
F468 62568
SHOFEA & DTRIG
F474 62580 terra
F511 62737 heigh
F515 62741 attri
F563 62819 mulco
F5B9 62905 featy
F5BA 62906 code
F5BD 62909 featu
F622 63010 fh
F623 63011 lh
F624 63012 hh
F625 63013 abh
F62F 63023 taba1
F639 63033 taba2
F643 63043 taba3
F64C 63052
TERRA
(incl. HEIGHT & FEATUR)
F654 63060 sinta
F695 63125 sinco
F6D4 63188
SINCOS


Memory map for machine code parts of The Forest
F6E0 63200 title
F6EB 63211 copyr
F742 63298 init INITIALISE
F7C7 63431 vars GLOBAL VARIABLES
F807 63495 const INITIAL VALUES
F820 63520
F870 63600 "Run"
63604 "Thick"
63610 "Moor"
63615 "Grass" TERRAIN NAMES
63621 "Lake"
63626 "Town"
63631 "Depression"
63642 "Knoll"
63648 "Niche"
63654 "Boulder"
63662 "Building"
63671 "Ruin" FEATURE NAMES
63676 "Root stock"
63687 "Sheep fold"
63698 "Mine shaft"
63709 "Rock outcrop"
63722 "Pond"
63727 "Water tank"
63738
F901 63745 attr
F902 63746 addtt (t)
63748 adtex TSHOW
63750 tshow STRING DISPLAY
F90D 63757 tø
F96A 63850 attrø
F96C 63852 cls CLS CLEAR SCREEN
63900 glake
63929
64000 gflag
64089
64100 gmoor
64159 GRAPHIC STRINGS
64200 gtown
64389
64400 gfir
64589
64600 grun
65159
FEB0 65200 addtt (g)
65202 adgra
65204 gshow GSHOW
FEBB 65211 gø GRAPHIC DISPLAY
65281
65368
FFFF 65535 U.D.G. (not needed for run time)

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PRESS RELEASE

AND NOW FOR SOMETHING COMPLETELY DIFFERENT

"The Forest" is the title of a new program released by Phipps Associates for the 48K Sinclair Spectrum, which is certainly different from anything seen before for this versatile computer. The program simulates the terrain as seen by a runner competing in an orienteering event. With every step or change of direction the scene changes to reflect the movement through the countryside.

Armchair running might seem a contradiction in terms, but the program can be enjoyed at several levels. It is a very enjoyable game in its own right, trying to 'run' round the course in a new best time, without falling into the lake or getting lost. For the orienteer it is a valuable training aid to hone up during the winter months on his map reading techniques so as burst forth next Spring ahead of the field. The main techniques which it teaches are those of "aiming off" - heading for a more prominent feature which cannot easily be missed instead of the control point itself; also "contour following"- running at a constant height so as to follow a contour line drawn on the map.

One course is preset in the program, but other courses can be made up using the course planner's menu and saved on tape for later use. Two different types of terrain are also known to the program. The second type is more like the terrain of Scandinavia, the home of orienteering. For the Geography student there is also much of interest, since features are included for drawing three dimensional diagrams of the terrain, contour maps and feature maps. The territory known to the computer is not confined to that covered by the map included with the game - it extends 37 kilometres around the map in every direction. Would be map makers can practise by mapping some of the adjacent

J. G. W. PHIPPS, MA,AMBIM,MBCS : T. R. TOMS VAT REGISTRATION No. 339 8307 29

squares. All of the Scandinavian territory referred to above is unmapped - there may be elephants lurking in the undergrowth, who knows? Geography teachers will also find the program invaluable for teaching the relationship between maps and the actual countryside, when weather or other factors prohibit actual field work being done.

The author Graham Relf is a Physics graduate of Imperial College London and St. Andrews University. He works in the computer field on software image analysis. His hobbies include map making and orienteering and he produces special maps for orienteering events including the British Championships in 1981. He is at present preparing the map for an international orienteering event to be held in Northumberland in 1985.

The game comes packaged in a custom built plastic folder with a 32 page book of instructions, a special four colour map drawn according to orienteering conventions and the program tape itself. The program is priced at £9.95 retail.

For more information please contact:

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Trvor Tams	Ø1/393/Ø283	(Home Aylesbury 27846)
Graham Relf		(Home Prudhoe 32503)

Bob Chappell takes a crash course in orienteering in the comfort of his own front room.

Into the Forest

I was sure it had nothing to do with a certain East London soccer team. Maps were involved somewhere along the line, yet more than that I could not say. The ignorance is now resolved and I am a changed man. I have been through The Forest.

As you're probably wondering what on earth I'm on about, let me explain in one word — orienteering. The instrument of my education was a program called, unassumingly, The Forest. If you know as little about orienteering as I did, then this program is probably the best practical introduction to the sport you could find.

The Forest is a simulation of the sport of orienteering. With it you can travel miles through the toughest terrain without ever leaving your fireside chair. Orienteering can most simply be described as car rallying on foot, being a cross-country race over difficult terrain, often forest, with the extra dimension of having to navigate your own course.

Armed with a special marked map and a compass, you have to plot and follow your route between a number of control points from the start to the finish. At each control point, a control card is marked as a verification that all the correct checkpoints have been visited. The art lies in successful map reading as much as being fast on your feet.

The program is intended as a training aid for practising the techniques of orienteering and can be used in teaching the understanding of maps and their relationship to the physical world. It also happens to be a very entertaining and demanding sport simulation in its own right and will undoubtedly appeal to those games-players who like their pleasures to be more cerebral. Tackled as a race, yomp or steady stroll, it offers many interesting challenges during the course and much satisfaction on successful completion.

A detailed map of the course is supplied with the package. The screen views the terrain directly ahead. All visible features (trees, towns, lakes, etc) are shown on the horizon which is six metres away. The view covers a 100 degree sector, 50 degrees to each side of the centre. Movement through the countryside is controlled by the cursor keys. Pressing the left or right arrow key faces you 11.5 degrees to the left or right respectively. Pressing the down arrow causes a 180 degree about-face. The up arrow sets you moving forward, each step being about 1 metre. To stop running press any key except the up arrow.

The direction you are facing can also be changed by altering your bearings; these can be taken and changed at any time. With every change of direction, the display is updated accordingly. A list of the control point codes and descriptions can be displayed, as can your control card which may be punched at any control point. The time elapsed since you started off is displayed on request.

Assistance can be obtained by calling up a menu and getting your current co-ordinates, enabling you to verify your position against the map. Any part of the terrain can be displayed as terrain type, as contours, as a cross-section, as a three-dimensional view, or can be scanned for point features. These features are not there just to get you out of a jam but are intended to instruct by showing the relationship between the map and the ground in a variety of ways. These features are most impressive and geography teachers could find them invaluable as a teaching aid.

You can give up before you've finished — the display tells you which of the control points marked on your card are correct or missing. There is an option to try out the same course on a more complex forest, which is considerably more difficult.

One might think that having completed the course once or twice the challenge would disappear. Not so, for the author has provided a facility to set out your own course over the mapped area. There are a large number of control points laid out in the terrain, only a few of which are used in the preset course. By following a simple question and answer menu, you may use any of these control points to construct your own course. The only restriction is that the start and finish points must be those used in the preset course.

Being able to design then save these courses to tape extends the interest value of the program indefinitely. With the additional element of competing against the clock and the various facets of the mapping aids, the program offers vast scope for entertainment and instruction.

Presentation

The whole package has the hallmarks of quality and professionalism. The program comes on cassette packed in a large video-style case. The program is copied to both sides of the cassette and it loaded first time, every time. Inside the case is the printed map. It is very well produced and the scale and legends are clearly marked, as is the course.

The 32 page book that comes with it provides an introduction to orienteering and covers all the features of the program clearly and concisely. There are helpful diagrams complementing the text which assist in understanding trickier concepts such as map orientation for three-dimensional displays.

Although I knew precious little about orienteering before I picked up this book, I found that I could quickly become proficient in using the program effectively and, more to the point, understand precisely what was going on and why. The book is lacking in two places only — in setting up your own course and in restarting the program. Apart from that, the documentation, like the program, is first-rate.

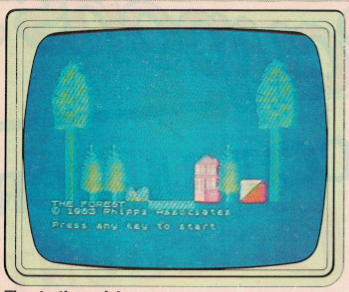
Getting started

Although the program is very easy to operate, you are well advised to study the manual before plunging into The Forest. Of particular importance is the recommendation to use a protractor for taking bearings on your map. The manual gives invaluable advice on navigational techniques — following boundaries, counting paces, lining up on landmarks, checking bearings, etc. I ignored this expertise to start with and, although I had no problems in using the program and made considerable progress across country, I ended up way off course.

On running the program, you are immediately presented with a colourful view of trees and part of a town. This is

35 ▶

Johanne Ryder



The starting point.

◀ 33

the starting location. Typing shifted B shows your current bearing and invites you to enter a new one. Having done this, pressing the upward arrow sets you off at a steady pace in the direction selected by your bearing. The scene is quickly updated with every step taken.

In real life, you would be almost certain to drift slightly from your set course, and since the program emulates this tendency it is worthwhile checking your bearings at regular intervals. Failure to do this had me missing the first control point and having to retrace my steps. Pressing any key other than the upward arrow causes you, and the displayed scene, to remain motionless — but time marches on. Pressing the left or right arrow key while moving has the scene sliding smoothly sideways in the desired direction.

The manual clearly explains the displayed symbols and offers advice on navigating for the control points. With this guidance, I found it very easy to get started and soon had the first three of the 12 control points stamped on my card. It was not long after that that I became hopelessly lost and had to resort to 'cheating' by calling up the assistance menu. This put me back on the right track, although I had wasted a lot of time looking for the control flag in the wrong place.

In use

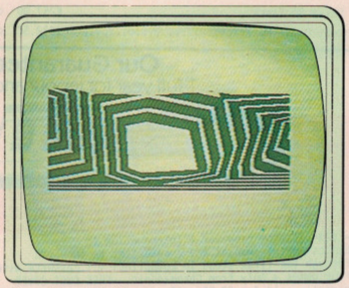
The graphic display, with its representations of thicket, houses, moor, grass, lakes and buildings, gives a clear impression of the terrain before you. Eye level is represented by a central square and, as the scene varies in height, it is easy to determine whether you are going uphill or down. Colours are used naturally and effectively.

The contour map option allows you to select a fine or coarse map of an area. If the latter, the contour interval can be chosen and the resulting map coloured and lettered (the higher the letter in the alphabet, the higher the contour). Maps can be scaled or drawn covering a given width and height. The orientation of the map can also be specified.

Mapping the terrain gives a coloured and lettered representation of the area, each letter repeseting a type of terrain (*eg* g for grass, m for moor, etc).

The point features option allows the scanning of a particular area. The display is exactly how you see it when in the normal mode of traversing the countryside. The scan runs up and down the area in raster scan fashion, covering a strip at a time, just like a lawn mower. The scan displays the co-ordinates at every step and halts at any section containing any point feature (knolls, depressions, boulders, etc) within it — useful for checking out the names and locations of the control flags.

A cross-sectional view of an area can be taken and a three-dimensional view of a particular area can be obtained. In the latter, being able to specify the orientation of the view is especially useful.



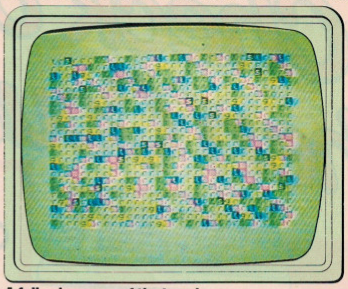
The ordinary contour map.

Setting up one's own course is simple, but you have to know the names and associated descriptions of the control flags you are going to use. Since these can only be found by exploring the terrain (they are not marked on the map or listed in the manual — that would spoil the fun), you need to build up this list yourself. You can't enter new flags or descriptions. Co-ordinates of the control points for your own course do not need to be specified, only the flag codes and associated descriptions. You can have up to 20 control points on your course.

Reliability

The single key commands and menu of options make the program easy to use. When you have completed a course, your card is displayed along with the time, markings and number of times you cheated. At this point the program is halted by a STOP statement. If you wish to have another race, the manual tells you to type in GOTO 4.

The program loads in two sections — what the manual doesn't say is that you should rewind the tape to the beginning of section two (or even to the beginning of the reel) before executing the GOTO otherwise the program will hang, not being able to find that section to load. One might just as easily power off and on, and reload from scratch.



A full colour map of the terrain.

Punching your control card with the wrong flag code or against the wrong control point is possible, but then this would be possible if you were really orienteering. It is necessary to use the D option to check the control codes and descriptions before punching your card.

Don't think you can cheat by learning the codes for each of the course points, punching them out on your card and going straight to the finish. The program won't let you punch a control on your card unless you are close by the flag in question.

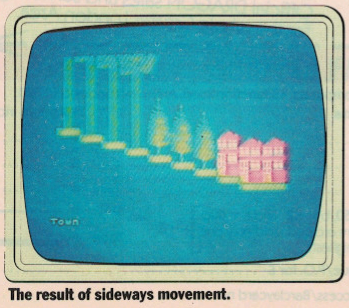
Verdict

An exceptionally absorbing program and one that is certain to sustain one's interest over a long period of use. If you are looking out for a program that is original, entertaining, instructive, intellectually satisfying and has an unlimited interest span, then I unreservedly recommend The Forest to you. I just hope that this is but the first in a long series of orienteering programs from Mr Relf and Phipps Associates.

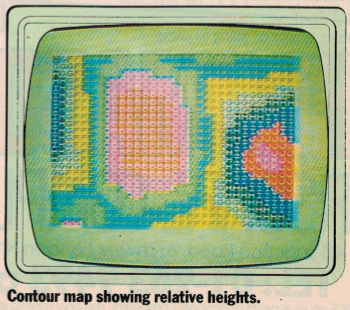
Name The Forest **System** Spectrum (48K) **Price** £9.95 **Publisher** Phipps Associates, 172 Kingston Road, Ewell, Surrey KT19 0SD Tel 01-393 0283 **Format** Cassette **Language** Basic and machine code **Other versions** None **Outlets** Mail order and dealers

RATING

Features	
Documentation	
Performance	
Usability	
Reliability	
Overall value	



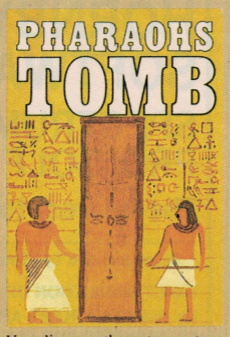
The result of sideways movement.



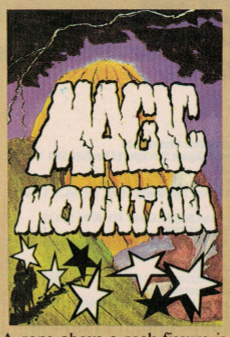
Contour map showing relative heights.

48K ZX SPECTRUM ADVENTURES – PICTURE GRAPHICS AND COLOUR

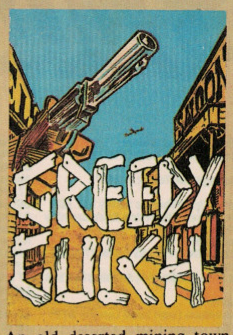
You are a Knight of Camelot, searching for Merlin's lost treasure. On your way you will discover the Witches' Tower, rescue a Princess held by the wicked Wizard of Trill. **£5.95**



You discover the entrance to an ancient pyramid blocked by a rock. Once inside, you discover fire rooms, ice rooms and other traps set by the builders to protect the Pharaoh. **£4.95**

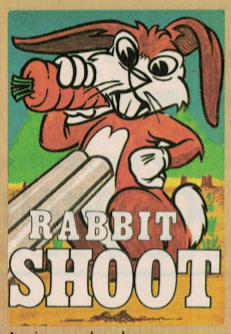


A rope above a rock fissure is the only way into this Magic Mountain, or is it? Legends tell of vast stores of treasure but also of poisonous spiders, lizards and magic at work. **£4.95**



An old deserted mining town holds the clues to the location of a lost gold mine. Once in the mine, your problems are not over – the roof creaks alarmingly and might cave in. **£4.95**

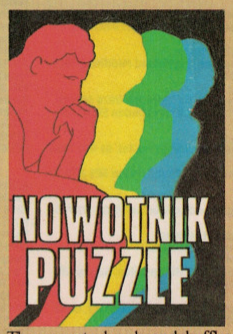
16K ZX SPECTRUM GAMES AND PUZZLES



It is nearly dawn, you are poaching rabbits in a field of carrots. See how many you can bag undetected by the game keeper. Highly original arcade style game. **£4.95**

The cassette of the book. Contains six games (including Castle Walls, Great Fire of London, Reversi) machine code assembler, disassembler. **£5.95**
Book available separately **£6.50**

The traditional game with superb screen presentation. Score points by making the two ends add to a multiple of five or three. The first one to reach 72 points wins. **£4.95**



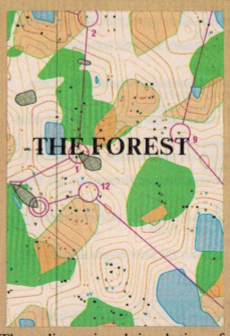
The computer breaks and shuffles a two by two coloured square, whilst you watch the moves it makes. You must then unscramble it to reassemble the original squares. Machine coded. **£4.95**

48K ZX SPECTRUM GAMES

16K ZX81

To find the Black Planet you need 7 pieces of the key each hidden on different planets, and needing different puzzles to be solved. On the way, you fight off the pirates who get steadily more desperate. **£5.95**

You are Spectrasses, battling in the arena with Gorgon, whose stare can turn you to stone. To recover the lost chalice, you must also win a swordfight with Grang, inside his cave. **£4.95**



Three dimensional simulation of the sport of orienteering. Display is continuously updated as you run. Ideal for map reading practice. Instructions, colour map and cassette. **£9.95**

For the ZX81, three adventures – black and white text. Magic Mountain, Pharaoh's Tomb, Greedy Gulch, as described above. Superb value for money. **£5.00**

PHIPPS ASSOCIATES

Dept G … T EM463 (No stamp)
172 K… …Ewell, Surrey KT19 0BR
Telephone … 3 0283. 24 Hour answering.

Prices include postage (outside Europe add £1.00 per item). *Access a… …n cards welcome*

FRONTLINES

Your Spectrum, June 84

FORESTRY COMMISSION

Calling all *Forest* devotees, Have you been amazed to discover that yo never run off the edge of the action although *your* map is only 2Km by 2Km? Then grab pen and paper and immediately send off for your *Complex Forest* map from Phipps Associates, 172 Kingston Road, Ewell, Surrey (or phone 01-393 0283).

PARK IT IN THE ROM

Parker has moved into the home micro market with

NEW 'FACE FOR THE SPECCY

Ram Electronics, the Fleet-based hardware company, recently announced the launch of a new 'multi-purpose' Spectrum interface.

The device, modestly named the 'Ram Turbo', accepts Sinclair ROM cartridges and two joysticks of the standard 9-pin 'D' connector type. At this point you may be thinking this sounds rather like one of Sinclair's own Speccy add-ons — and you'd be right.

Although the Ram Turbo is £3 more expensive than the ZX Interface 2, it looks more futuristic and has a couple of extra design features. A unique built-in safety device prevents the user from inflicting expensive damage on the Speccy — the power cable can only be connected once the interface is in place. The Turbo also offers a full expansion bus (unlike Interface 2) which means there are no restrictions as to what other bits you may be thinking of bolting on the back.

"We expect to sell over 50,000 Turbos in the first three months alone," says technical director Martin Shoebridge. "Technically it's miles ahead of any competitors (surely not a dig at Uncle Sir C!) but most people want it yesterday — not next month."

We trust this isn't just the latest contender for the Flying Pigs department. More information, etc., from Ram Electronics on 02514 5858.

The futuristic Ram Turbo incorporates a unique built-in safety device.

ON THE CARDS 1

HOBBIT HACKERS

For all of you who bought *The Hobbit*, avidly read the book, tried to play the game and were *still* confused,

Further information

The Forest is archived on the **Spectrum Computing** web site.

A 1984 review of the original version, in **Crash** magazine.

Since 2014 I have redeveloped **The Forest** using more recent technology: Javascript running in browsers. This has made it possible to do far more things in the program and with much better graphics: photographs of real trees and landscape features, plus detailed contour maps to proper orienteering standards. This new version may be played for free at grelf.itch.io/forest It includes a lengthy treasure hunt as well as the orienteering courses.